TYPICAL BUTTERFLIES.

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"WILD ANIMALS I HAVE KNOWN," ETC.

ILLUSTRATED WITH
Seventy-two Colored Plates and Two Thousand Engravings

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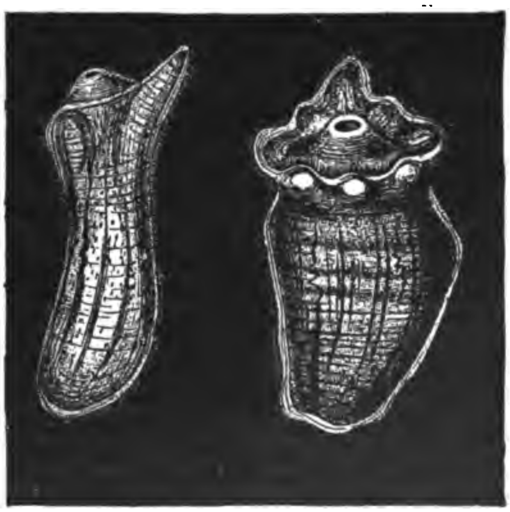


LIBRARY OF NATURAL HISTORY

VOL. VI

INVERTEBRATE ANIMALS

CHAPTER I

THE JOINTED ANIMALS—Subkingdom **ARTHROPODA**

THE INSECTS — Class **Insecta**

ANTS, WASPS, BEES, ETC.— Order HYMENOPTERA

Distinction between Vertebrates and Invertebrates

IN THE early days of zoological science, when the value in classification of the structural and embryological characteristics of living beings was but little understood, the animal kingdom was divided into two subkingdoms called Vertebrata and Invertebrata; the former embracing those forms provided with a vertebral column, or backbone, and the latter those that were not so provided. With the addition of some few classes, whose organization has only recently been fully comprehended, the Chordata of to-day are coextensive with the Vertebrata of half a century ago. But the term Invetebrata, as denoting a natural assemblage of animals, has long ceased to be used by every competent zoologist, and is nowadays merely applied as a con-

veniently vague title for all the animals that have not acquired the characteristics of the Chordata. This change of opinion has been brought about by the attainment of a far more intimate acquaintance with the structure and development of the lower animals than our predecessors, with their less refined methods of investigation, could possibly possess; and it has resulted in the splitting up of the so-called invertebrates into a number of subkingdoms, each of which is equivalent to the entire group of Chordata.

It must not, however, be supposed that no advance has been made of late years in chordate morphology, and that the conception of the essential characteristics of the group is the same as it was in the earlier part of the century. So far indeed is this from being the case, that the zoologists of those days would certainly be greatly puzzled to understand the reasons for the present wide extension of the group to embrace such forms as the sea squirts and the worm-like *Balanoglossus*, which have no vertebral column, and do not even present the outward semblance of any of the classes of the true Vertebrata. Strictly speaking, therefore, they are not Vertebrates at all; yet their claim to be ranked in the same great category of animals as the lancelet, which also has no backbone, and the fishes is now generally accepted, and is based in the main upon their possession, in common with all the true Vertebrates, of three characteristics not found in any other group of the animal kingdom. These are, firstly, the presence of slits in the lateral walls of the pharynx, by means of which the anterior part of the alimentary canal is put into communication either with the body cavity or directly with the outer world; secondly, the existence, either as a temporary or permanent structure, of a cartilaginous rod, the *notochord*, lying lengthwise in the upper part of the body; and thirdly, the position of the principal nervous tract, also in the upper part of the body, but above the notochord. The fate of the notochord in the different classes of Chordates is somewhat varied. In some of the sea squirts, for instance, it persists only in the tail, which may entirely disappear when the animal settles down to its sedentary life. Hence these creatures are sometimes called the Urochordata, or rod tailed. In the lancelet, however, this structure remains throughout life, and extends from the end of the tail to the extremity of the head. Hence the section containing this little fish-like creature is called Cephalochordata, or rod headed. In all the higher members of the assemblage, however, that is to say, in fishes, amphibians, reptiles, birds, and mammals, the notochord falls short of the front end of the head, terminating just behind a point which in the floor of the skull eventually becomes the pituitary fossa. Moreover, in all the forms that acquire a bony skeleton, this rod is to a greater or less extent replaced by the bodies, or *centra* of the vertebræ, or segments composing the backbone; these centra supporting the bony arches developed for the protection of the dorsal nerve chord. No less varied is the fate of the pharyngeal slits, or visceral clefts. Whereas in the lower Vertebrata, such as fishes, these remain as the branchial slits, in the adults of the more highly organized forms, like mammals, they practically disappear, one only remaining as the eustachian tube, by means of which the back of the mouth communicates with the inner chamber of the ear.

With this briet résumé of the fundamental features of Chordate morphology, we may turn to the remaining groups of animals, the so-called Invertebrata, which, as a whole, may be distinguished from Chordates merely by negative characteristics, there being no pharyngeal slits, no notochord, and no central nervous system running along the back. Nevertheless, some of the higher groups of invertebrated animals — such as the Arthropods and Mollusks — resemble each other, and differ from the Vertebrates in the arrangement of some of the principal organs of the body. For instance, although as in chordates the front end of the nervous chord is lodged in the head above the mouth, and constitutes the brain, the rest of it runs along the ventral or lower surface of the body beneath and not above the alimentary canal, which thus, in its anterior or œsophageal part, passes right through a ring or collar of the nervous system. Again, the chief centre of the circulation, the heart, is lodged in the back and not in the lower part of the body, so that the arrangement of these two structures is exactly the opposite of that which obtains in the Chordata. If, for example, a transverse section be cut through a fish a little behind the head, the nerve chord, the alimentary canal, and the heart will be found to occupy the following positions — the first named being in the back, the second in the middle, and the third below: while, on the contrary, a section of the same kind, taken in substantially the same place in a centipede, will show that the heart is above, and the nerve chord below the alimentary canal.

This arrangement of the organs in question does not, however, exist in all invertebrated animals. In some the nervous system is absent; in others it consists of two strands, one running along each side of the body, and neither above nor below the alimentary canal. In others, again, there is no circulatory system, and in others no alimentary canal. There is consequently an extreme divergence in anatomical structure between various kinds of Invertebrates, and zoologists have attempted to express these differences, as explained above, by referring these various creatures to distinct subkingdoms.

Eight of such subkingdoms are provisionally recognized in the present work, and are arranged as follows: — (1) Arthropoda, or Invertebrate animals with jointed legs, such as insects, spiders and crustaceans; (2) Echinodermata, or starfish, sea urchins, stone lilies, etc.; (3) Mollusca, or soft-bodied, unsegmented animals, often with a shell, but without legs, like cuttlefish, whelks, and oysters; (4) Molluscoidea, including the lamp shells and corralines; (5) Vermes, or worms and their kindred; (6) Cœlenterata, or jellyfish, seaanemones, and corals; (7) Porifera, or sponges; and (8) Protozoa, or single-celled animals, like the microscopic foraminifera. As the special characteristics of each of these subkingdoms are pointed out in the chapters devoted to them, no further reference is necessary in this place.

Special Characteristics of Arthropods

The term Arthropoda is applied to the classes of animals composing this subkingdom in allusion to the fact that the limbs are divided by joints into a series of movable segments. The title, however, is not in all respects satisfactory, seeing that members of other groups, mammals and birds for instance, also have jointed legs, and in one important though not typical class of Arthropoda, namely, the Prototracheata, containing the aberrant family *Peripatidæ*, the appendages are short and undivided. The

name is consequently often superseded by the later but more appropriate term Gnathopoda, meaning foot jawed, which refers to a characteristic that is perfectly distinctive of all the species included under the heading. This is the transformation into jaws, or *gnathites*, as they are sometimes called, of one or more pairs of the appendages that lie at the sides of the mouth, or just behind it. The number of pairs involved in the formation of jaws varies from one to six, the smallest being found in *Peripatus*, and the largest in crabs and their allies, while between these two extremes we meet with two pairs in the Millipedes, three in the Insects and four in the Centipedes.

The appendicular nature of the jaws, then, is the most distinctive feature of the animals now under discussion. But if two members of the Arthropoda, say for instance a lobster and a centipede, be compared together, they will be found to possess many other structural characteristics in common. Thus the body is bilaterally symmetrical, that is to say, if it be cut exactly in half lengthwise, the right and left portions will be precisely alike. It is, moreover, divided into a series of segments, placed one behind the other in a long series; each segment bearing a pair of limbs, which in the centipede are all alike, but in the lobster vary considerably in size and structure in different regions of the body. In both types, moreover, some of the segments at the front end of the body are modified by fusion, and in other ways, to form a head, which is furnished with eyes, and bears, in addition to the jaws, appendages that have been transformed into long, many-jointed feelers, called antennæ. In the lobster, however, there are two pairs of these organs, while in the centipede there is but one.

These external resemblances are correlated with others connected with the internal anatomy. The alimentary canal, for instance, traverses the body from end to end; and the nerve chord lying beneath it consists of two adjacent strands united in the separate segments, the points of union being marked by swellings called *ganglia*, from which nerve threads radiate to the neighboring parts. Above the alimentary canal comes the heart, and this organ, although superficially very different in the two types, is yet constructed upon the same general plan. In the centipede it is long, tubular, and composed of many distinct segmentally-arranged chambers, and furnished with arteries for the distribution of blood to the tissues, and with slits or *ostia* by which the fluid again makes its way back to that organ. In the lobster, on the contrary, the heart is short, thick, and consists of a single chamber, but is nevertheless provided with the arteries and slits as in the case of the centipede.

The dissection of these two creatures would, however, reveal one fundamental difference between them. In the centipede it would be noticed that the body is supplied internally with a rich system of branching tubes which open on the exterior by means of apertures placed in the sides of the segments. These tubes are known as *tracheæ*, and their apertures as *stigmata*. They, or similar structures, are found in nearly all Arthropods that live upon the land and breathe the oxygen in the air. They are, in fact, the breathing organs, and analogous to the lungs. The lobster has no such system of tubes; for living in the water, and breathing the oxygen dissolved therein, this crustacean has need of a different type of respiratory

organ analogous to the gills of fishes. These it possesses in the form of delicate plumes attached to the bases of the walking-legs and the sides of the body just above them; and although concealed from view and protected from injury by a large plate, these gills are yet freely exposed to the water in which the animal spends its existence. Gills resembling those of the lobster in function, and also substantially in structure, are found in almost all Arthropods that live in the sea.

The characteristics that have been here briefly alluded to in the description of the anatomy of the centipede and lobster will be found to be equally discernible, if other prominent types of Arthropoda be examined. Differences of course will be found to exist; but, on the whole, the plan of structure that has been sketched is true for all the classes. For instance, in all of them, except the Centipedes and Millipedes, there is a tendency in the more specialized members toward an increase in size of the limbs in the front half of the body, accompanied by a corresponding dwindling of those in the hinder part. Thus a crab and a spider walk upon four pairs of legs placed just behind the head, and an insect upon three; and in the case of the insect the legs of the hinder region have entirely disappeared, while the larger number of them have similarly vanished in the spider and the crab. There is also a tendency in the higher members of each class for the ganglia of the nervous chord to lose their segmental arrangement, and to become concentrated together in one large mass, placed near the seat of the greatest muscular activity. Nevertheless, underlying all the modifications of structure — however extensive these may be — there is a common plan of organization which may be regarded as typical of the Arthropoda. This may be briefly sketched as follows: The long bilaterally-symmetrical body is divided into a series of approximately similar segments, each bearing a pair of similar and segmented limbs. These limbs are the organs of locomotion; but some of those at the front end of the body, where comes the mouth and the organs of vision, take on the function of jaws, and are used for seizing and masticating food instead of for progression. The nervous system consists of a double ventral chord with ganglionic enlargements in each segment, and the first ganglia of this ventral chain are connected by means of a chord on each side of the œsophagus with the brain, which is lodged in the head. The heart, lying above the alimentary canal — which runs from one end of the body to the other — consists of a series of chambers, one for each segment of the body, and is provided with arteries for the distribution of the blood, and with slits or ostia for receiving it back again.

The Arthropoda are divided into the following classes, the chief characteristics of which are described further on — (1) Insects (Insecta, or Hexapoda); (2) Centipedes (Chilopoda); (3) Millipedes (Diplopoda); (4) Spiders, Scorpions, Ticks, etc. (Arachnida); (5) King crabs (Gigantostraca); (6) Crustaceans (Crustacea); (7) Prototracheata (*Peripatus*).

It is possible, however, to group these into larger divisions. The insects, centipedes, and millipedes, for example, may be placed together as Tracheata, characterized by the possession of tracheæ and of a single pair of antennæ. The Crustacea stand alone in having two pairs of antennæ and in breathing with gills. By means, however, of the extinct class of the Trilobites, they are connected with the king crabs; and these in possessing only six pairs of well-developed anterior

limbs, and in having no antennæ, strikingly resemble the Arachnida. *Peripatus* is very peculiar, but shows signs of distant relationship with the centipedes, although in many anatomical features it is not very far removed from the worms.

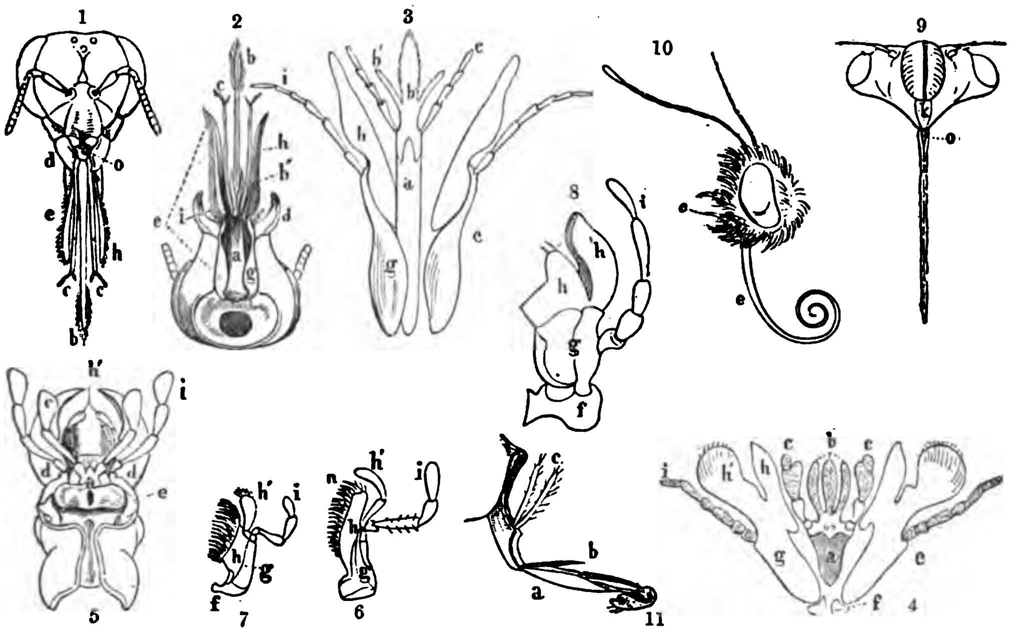
Distinctive Characteristics of Insects

The term insect, although originally and, according to the meaning of the word, correctly employed in a wide sense to embrace all those animals in which the body is externally divided into a number of segments, including, of course, butterflies, beetles, bugs, spiders, scorpions, centipedes, millipedes, not to mention crabs and shrimps, is now, by common consent, used in a much more restricted sense to apply solely to such members of the Arthropoda as have only six walking legs. In allusion to this feature the class is nowadays often called the Hexapoda, the term being much more precise and applicable than that of Insecta. In addition, however, to the possession of six legs, insects are characterized by certain other well-marked features, serving to distinguish them from all other arthropods. The body is divided into three distinct regions, arranged in a longitudinal series, and named respectively, from before backwards, the head, thorax, and abdomen.

The head, which varies much in size and shape in different groups, bears the eyes, the antennæ, and the jaws. The eyes are of two kinds, simple and compound. The latter, of which there is a single pair, situated one on each side of the head, and often so large as to occupy the greater part of its right and left half, consists externally of a multitude of lenses, often exceeding many thousands in number. The simple eyes, or ocelli, on the other hand, are fewer in number — usually only two or three — and placed upon the fore part of the head. The antennæ are movably articulated by means of a special socket to the front of the head, usually below or near the inner edge of the compound eyes. They vary much in structure and length, being sometimes long and pliable, and composed of a large number of segments, as in the cockroach, and at other times short, like those of the house fly, and consisting of a few segments only. There is no doubt that the antennæ contain highly important organs of sense, the bristles with which they are studded being probably tactile, and some of the other organs possibly olfactory in function.

The front edge of the head, or its lower edge when carried vertically, is often movably jointed to the rest of it, and constitutes an upper lip, or labrum. In the formation of the jaws, which are attached to the lower surface of the head, three pairs of appendages, respectively named the mandibles, the maxillæ, and the labium, are involved. But these parts are susceptible of an extreme amount of variation in structure and function, being sometimes formed for mastication, as in the mandibulate forms, such as the cockroaches and beetles, and sometimes for piercing or sucking, or both combined, as in the so-called sucking forms like the flies, butterflies, and bugs. There is no doubt that the mandibulate type of mouth in which the gnathites, or jaws, are more foot-like in structure, is the most primitive of all. In this case the mandibles usually consist of a stout pair of one-jointed skeletal pieces, the inner edge of which is furnished with biting teeth. Sometimes, as in the males of stag beetles, the mandibles are enormously large, and simulate horns. The maxillæ are much more complicated in structure; each consists of a basal piece, composed of two segments — the cardo and stipes — from which spring two

branches, an outer or palp, which has the appearance of a dwarfed limb, and an inner, which is in its turn double, the inner blade being called the lacinia, and the outer the galea. The jaws of the third pair, constituting the so-called labium, or lower lip, are constructed upon the same principle as the maxillæ, but the parts usually considered to correspond to the cardo are united to form a plate — the mentum — which is articulated by its hinder part to a sternal plate of the head, called the submentum. In front of the mentum there are externally the jointed palpi, resembling those of the maxillæ, and between these there is a median, sometimes bilobed, piece, called the ligula, and a pair of pieces termed the paraglossæ. The



MOUTH ORGANS OF INSECTS.

1. Head of honeybee, from the front; 2. Head of humblebee, from below; 3. Maxillæ and labrum of a bee (*Andrena*); 4. Maxillæ and labium of sawfly (*Cimbex*); 5. Lower view of head of carnivorous beetle (*Procrustes*); 6. Maxilla of carnivorous beetle (*Cicindela*); 7. Maxilla of cock-tail beetle (*Staphylinus*); 8. Maxilla of locust; 9. Head of bug (*Cicada*) from the front; 10. Head of butterfly; 11. Head of horsefly (*Tachina*).

Labium — *a*. mentum; *b*. ligula; *b.'* paraglossæ; *c*. palp; *d*. mandible. *Maxilla* (*e*), with *f* cardo; *g*. stipes; *h*. lacinia; *h.'* galea; *i*. palp; *k*. head plate; *n*. teeth on lacinia.

degree of development of the several parts varies greatly in different orders, and it is often a matter of considerable difficulty to determine the exact correspondence that exists between them in two insects belonging to different orders. This is especially the case when the jaws have been modified to form the different organs of suction that are met with. The structure of these will be described in detail when the species that possess them are discussed. Another organ to be mentioned in connection with the jaws is a membranous lobe, called the hypopharynx, or tongue, projecting into the interior of the mouth from the floor of the labium.

The thorax, or median part of the insect's body, is formed of three segments called the pro- meso- and metathorax, each of which is composed of several distinct

pieces. The dorsal areas of the three segments are termed the pronotum, mesonotum, and metanotum; the lateral regions the pleuræ; and the inferior regions the sterna. To the pleuræ are articulated the three pairs of legs, each of which consists primarily of five segments, named respectively, from the base to the apex, coxa, trochanter, femur, tibia, and tarsus; the last, which constitutes the foot, being generally tipped with two claws, and subdivided into several—often as many as five—smaller segments. To the sides of the upper surface of both the meso- and metathorax are usually attached a pair of wings, which are very characteristic organs of all the higher insects, although absent in the lowest forms, and in many species degenerate through parasitic habits. The wings differ much in structure, thickness, clothing, etc., in different orders of insects, but in all cases they seem to consist of an upper and a lower membranous layer, traversed by narrow bands of thicker material, the nervures.

The abdomen in insects is marked off from the thorax by the absence of true appendages. It may consist of as many as ten distinct segments, but never of more, and generally of fewer. Each segment is protected above by a dorsal plate, or tergum, and below by a ventral plate, or sternum, the two being connected laterally by membrane. The last segment is often provided with a pair of appendicular structures, which may be long, many-jointed, and antenniform, or short and one-jointed, like the pincers of an earwig. And, in addition to these, certain other structures, such as the stings of bees and wasps, and the ovipositors of locusts and ichneumon flies, are frequently connected with the hinder segments of the abdomen. The only other external structures that need be mentioned here are the stigmata, or apertures, of the respiratory organs. These pierce the lateral surfaces of the thoracic and abdominal segments, and vary much in number, size, and form, being generally far more plainly seen in the larvæ than in the adults. There may be as many as eleven pairs, but usually the number falls short of this.

In exceptional cases, as in the plant lice (*Aphidæ*) belonging to the order Hemiptera, and in certain parasitic flies of the group Pupipara, the young are born in an advanced stage of development, the eggs developing within the body of the parent without being first deposited. But in the vast majority of species the young make their first appearance in the world in the egg stage.

Between the time of its escape from the eggshell and the attainment of maturity, the young undergoes a succession of molts, or castings of the skin. In some cases the change of structure that an insect presents during the course of its growth is, comparatively speaking, trifling, the young being hatched in a condition in which in outward form it substantially resembles the parent in everything but size, and, in the case of species that bear wings in the adult, in the entire absence of these organs. A familiar instance of this method of growth is found in the cockroaches and grasshoppers, in which the young emerge from the egg as miniature and wingless copies of their parents.

In other cases, however, as in the flies (Diptera) and butterflies (Lepidoptera), an extraordinary change of form takes place during growth, the young upon hatching being so totally unlike the adult that no one unacquainted with the facts of in-

sect development would suppose the two to belong to the same category of animals. In these two orders, as well as in some others, the new-born young has the appearance of a fleshy grub; and the grub-like condition is retained unchanged, except in size, until the time for the last molt approaches. It then undergoes a startling change of condition, and, losing its organs of sense and ceasing to feed, passes into a state of quiescence, during which the final changes in its organization are more or less rapidly passed through, and the final molt sets free the mature insect, perfect in all its structural details.

The immature stages of insects that present a complicated development of this kind are variously spoken of as grubs, maggots, caterpillars, or more comprehensively, larvæ; while the quiescent stage is termed the chrysalis or pupa, and the final sexually mature stage the imago or perfect insect. Moreover, such species are said to undergo a complete metamorphosis, or to be holometabolous, as opposed to those like the cockroach, whose growth is accompanied by but little change of form, and are said to present an incomplete metamorphosis or to be ametabolous. It must not, however, be supposed that all insects are either completely or incompletely metamorphic in their development. The familiar types that we have mentioned exhibit almost, although not quite, the extremes of change that are offered in the class; but between these occur other types which show developmental phenomena more or less intermediate in their nature, being less complicated than those of the blowfly and more complicated than those of the cockroach. An account of these various methods of development will be given under each order as it is described.

Geological Age Like the Crustacea, Arachnida, Millipedes, and all the main divisions of the Arthropoda, with the exception of the Prototracheata (*Peripatus*), and possibly the Cintipedes, Insects are an exceedingly ancient group, having left their remains in strata of Silurian age. The exact nature and affinities of these primeval remains has not, however, yet been satisfactorily determined, and some authors indeed seem to doubt whether they are rightly referred to insects. Still there is no question that species of this group flourished in abundance during the Carboniferous period; but the conclusion that all the known fossil insects from these strata form a natural order, distinct from all the existing groups of this rank can hardly be regarded as finally established, seeing that, in the opinion of some authors, they are assignable to places in our classification of existing species, and are nearly related to the orders Orthoptera (cockroaches, grasshoppers, and dragon flies) and Hemiptera (bugs and plant lice). In the Secondary rocks insect remains, considering the small chances of the preservation of such creatures in stratified deposits are fairly abundant; and none of the species present ordinal differences from those which now exist. So, too, the hosts of species that have been discovered in Tertiary deposits, in the amber beds and elsewhere, are referable to existing orders.

Other Features It has been estimated that in numbers of species insects excel all other land animals of the world taken together, and a recent computation has put the total of described forms at 250,000, and yet, according to Lord Walsingham, only about ten per cent. of existing species have hitherto been discovered. But this is not the only respect in which the animals of this class

are in advance of all other groups. In brightness of color, beauty of pattern, and gracefulness of form some of the species can hardly be equalled even by the most gorgeous birds, while in mechanical perfection of structure, as testified by activity and strength, others of the group are unsurpassed in the animal kingdom. It has been stated that if a man could leap in proportion to his stature as far as a flea can hop, he could clear at a bound a wall over one hundred feet high, and if he could sing as loudly as the cicada, his voice could be heard for a distance of many miles. Indeed, even in matters about which a man is wont to especially pride himself, such as those touching social organization, he might with advantage go to the ant to learn wisdom, since many of the problems of modern civilization, involved in the questions concerned in the regulation of increase of population, the proper division of labor, and the support of useless individuals, have been satisfactorily solved by many of the species of insects that live habitually in communities.

Speaking in a general way, insects may be said to be terrestrial animals, since all the species are fitted more or less completely for atmospheric respiration and for progression on the land; many of them in addition are furnished with wings, whicb propel them through the air with amazing velocity. In many of the orders, however, as, for instance, in the beetles and bugs, there are species that have adopted an aquatic mode of life and spend their days in fresh-water ponds and streams in various quarters of the globe. Others again, like some of the gnats and dragon flies, live in fresh water during the larval stages of their existence, but quit it on attaining maturity. Insects, too, are sometimes found on the coast beneath stones and seaweed at low water, but there is only one species of insect that can strictly be called marine; this is a bug (*Halobates*) sometimes met with in numbers on the surface of the ocean thousands of miles from land.

Mimicry

The phenomena known as mimicry and protective resemblance are strikingly exemplified in insect life. The term mimicry is usually applied to cases where a species, otherwise unprotected, lives unmolested owing to its resemblance to another which is gifted with defensive weapons in the form of poison glands, or with a nauseating flavor that renders it distasteful. Such species as these are usually rendered conspicuous by contrasting patches of bright color. It is noticeable, for instance, that the patterns of bees and wasps are strikingly diversified, in order that the insects may be readily recognized and not slain by mistake for other species. Bees and wasps, then, being species that enjoy immunity from attack, are often imitated or mimicked by perfectly harmless flies and moths, and some beetles and animals allied to crickets similarly mimic ants. But the phenomenon of protective resemblance — or the mimicry of inanimate objects — by which a species is rendered practically invisible amongst its surroundings on account of its resemblance to a leaf, stone, twig, or bird-dropping, is of far commoner occurrence. On the accompanying plate a few instances of this kind of adaptation to surroundings are portrayed. Figs. 12, 13, and 18 are the larvæ or caterpillars of different species of Lepidoptera, the first two in color and shape simulating branches, and the last a snail shell; Figs. 1, 2, 9, and 14 are leaf-like pupæ or chrysalids of other kinds of Lepidoptera; while Figs. 3, 5, 7, 11, 15, 23, and 24 are the adult stages of members of the same order under different disguises.

MIMICRY IN INSECTS.

The most noticeable of these is Fig. 11, representing a large and handsome butterfly, which, when at rest, with its wings folded back, exactly resembles a dead leaf, even to the midrib and stem; while Figs. 23 and 24 exhibit two small moths, which might be readily mistaken for bird dung. In the Orthoptera, as the insects allied to the cockroaches and grasshoppers are called, the phenomenon is carried to an extent elsewhere unsurpassed in the animal kingdom. This is well shown in the case of the leaf insect (Fig. 4), the stick insect (Fig. 8), and the leaf-like locust (Fig. 10). Most of the other figures on the plate are of less importance. Attention, however, may be drawn to the water bug (Fig. 16), the young dragon fly (Fig 6), the beetle (Fig. 19), the curious bugs (Fig. 20), which in attitude and color closely approximate to the stems or bark to which they cling. Figs. 25 and 26 show two beetles resembling sheep's droppings. Fig. 17 exhibits one of the May flies like a dead leaf, and Fig. 21 two plant bugs which secrete threads of white wax and appear as tufts of woolen matter.

Characteristics of the Hymenoptera

The general characteristics of the Hymenoptera will be more or less familiar to most readers from their acquaintance with the well-known members of the wasp, bee, and ant tribes. The scientific name by which the order is known is derived from the fact that the upper and under wings on either side are linked to each other by a series of minute hooks on the one which cling to a fold in the membrane of the adjacent margin of the other. The group includes the sawflies, wood borers, gall and parasitic wasps, ichneumons, ants, spider-killing wasps, solitary and social wasps, and solitary and social bees. The number of species known is from 30,000 to 40,000, though from our knowledge of the proportion which they bear to other orders, it is computed that there may be upward of 150,000 species yet to be discovered. In specialization of structure they undoubtedly rank among the most highly developed of the Insecta. The neat, agile frame, hard shining integuments, stout mandibles, strong, light wings, and movable abdomen, bearing, in the case of the female, at its apex an ovipositor of great power and precision of application, or modified into an instrument for sawing and boring in some species, and in several families becoming a sting. All these features combine with a temperament of extreme nervous energy to give them a character for general intelligence, and a power of adapting means to ends such as are manifested in no other allied order. The web-making spiders alone resemble them in this respect, and we are able to find few analogies nearer than the intelligent action, individual or concerted, of man himself. The social Hymenoptera, such as ants, bees, and wasps have solved, on their own life plane, industrial difficulties and social problems, pressing for solution in the various societies of men. Doubtless this has been accomplished to a certain extent only at the cost of a loss of individuality such as civilized man would not tolerate for a moment. When we find that the worker ants, bees, and wasps have, during their specialization as workers pure and simple, lost their sexual faculties, that the members of a species of Amazon ant during their specialization as warriors have lost the power of even feeding themselves, being entirely dependent on slaves for their food, we may well pause before concluding that such solutions of important problems are in the end for the best, at any rate so far as concerns the human race.

Without entering into the more minute details of structure, the general characteristics by which the order may be distinguished are as follows: The possession of four transparent wings, a head, thorax, and abdomen distinct from each other, the latter joined to the thorax by a narrow stalk, or, in the case of the *Tenthredinidæ* by a broad uniting joint. The integuments are strong, hard, shiny, and often hairy. The mandibles are well developed for biting purposes, while the subordinate mouth parts are, in the case of the honeybees, modified to form a long tongue-like proboscis for extracting nectar from flowers. The head is more or less globular, bearing compound eyes and several ocelli on the crown between and just behind the antennæ. The mandibles are used, besides the mastication of food, for digging holes in the ground or for gnawing timber and various other purposes. In some ants the soldiers have the head enormously developed, as are also the mandibles; their function being to protect the society from enemies, and also to carry on war against neighboring communities. The antennæ are in most cases long, jointed, and filiform, constituting sensitive organs of touch and recognition. The thorax is composed of the usual three pieces, prothorax, mesothorax, and metathorax. It bears the wings, four in number, above, and the legs, six in number, beneath, the latter being modified in many species for special purposes, such as, in the bees, for gathering pollen from the blossoms of the plants visited for the sake of honey. Often the legs are armed with long spines, which in the sand wasps materially assist in the excavation of the pits in which these insects bury their victims and deposit their eggs. The wings are ample, strong, and light, formed of a transparent membrane strengthened with fine nervures or veins. The arrangement of these nervures varies much in different groups, and is of importance in the classification of members of the order. The relative importance of this characteristic is, however, not the same in every family, being in the sawflies, perhaps, of the greatest value. Species which are wingless in one or both sexes are found in many of the families; while in the genus *Oxyura* of the family *Proctotrypidæ* the wings consist merely of a fine central stalk with a battledoor-shaped plumose tip. The abdomen is united to the metathorax either throughout its whole width, as in the *Tenthredinidæ*, or, as in most other families, by a narrow stalk or petiole. These two characteristics serve for the division of the order into the groups of Sessiliventres and Petiolata. The organs of reproduction are situated at the apex of the abdomen; while in the female the instrument for depositing the eggs has become in the section Aculeata developed into a sting; in the *Ichneumonidæ* it is sometimes enormously long, and used for piercing the larvæ in which they lay their eggs. In the case of the large wood borers (*Sirex*) it is used as a boring instrument, while in the sawflies it is serrated on the edges and employed to wound the tender shoots on which the eggs are deposited. Among the *Pompilidæ* and some other families, the sting is used to paralyze the victim in which the insects lay their eggs, or leave in the cell to feed the larvæ as they hatch. Probably no pain is given to the victim, and even in the case of those grubs that feed internally upon the tissues of caterpillars in all probability less inconvenience is caused than we suppose.

In all cases the metamorphosis is complete. The egg may be laid in a cell prepared either by the female or the workers for the purpose, and the grub is fed by

the attendants on a preparation of pollen or other foods specially prepared. In other cases the eggs may be laid on the foliage of trees and plants on which the larvæ feed, or they may be deposited upon or in the bodies of living or paralyzed caterpillars, grubs of other species, or spiders, locusts, and the like. The *Cynipidæ* with the poison from their sting, and other causes combined, produce a large gall upon the leaves of trees, especially oaks; and on the fleshy cell structure of these galls the grubs feed when they emerge. Larvæ of two different kinds are met with in the order. Thus, whereas those of the sawflies have legs, sometimes even more in number than those of the Lepidoptera, the grubs of the majority lack functional legs. The former live a life of greater liberty, feeding on the foliage of trees; the latter are free, so far as they are not confined within an egg membrane, but being internal feeders, whether in foliage larvæ, wood, or shut up as solitary hermits, each in its several cell passes a larval period of limited freedom. It is a curious fact that the legs of some larvæ are more evident in an early than in the latter stages, thus proving that the habit of cell life is a comparatively recent departure from a former habit, when in all probability the larval life was passed in greater freedom.

Development The phenomenon of parthenogenesis is one which crops up in various orders of insects, being simply the production by the female of eggs or young without the fertilization of the egg germs within the female, by the stimulative elements necessary to the production of young in the higher animals. It is not, however, a chance phenomenon, appearing as a race-preserving expedient, on the sudden failure of male forms, but one of nature's resources for preserving the continuity of species. It is constant in many species of the Hymenoptera, in the form of what is known as the alternation of generations; in some species, however, it is supposed to be the sole form of reproduction, for the males of these species have never yet been discovered. Whether we regard the fertilization of the female egg germs by the male elements as dynamic or stimulative, or as merely a matter of the interchange of character determinants between the two sexes, it appears to be beyond a doubt that a continuous succession of virgin reproductions must inevitably tend to the degeneration and ultimate extinction of the race. Parthenogenesis or virgin reproduction may be of three kinds: First, resulting in the production of the male sex only; second, of the female alone; and thirdly, in cases when the young are produced not as eggs in the first instance, but alive, as in the case of the plant lice or *Aphidæ*. It seems that parthenogenesis does not favor the production of one sex more than another. We should, therefore, be cautious how we accept too hastily the commonly received belief that male bees are necessarily the offspring of nonfertilized eggs. It by no means follows that because an egg was not fertilized that therefore the sex produced in it is the direct result of nonfertilization. The question, however, is still a matter of controversy, and more evidence is needed before final conclusions can be reached.

That the members of this order are on the whole useful to man cannot be doubted,—more useful perhaps than the majority of insect forms,—whether as bees, with their honey-storing instincts, or as the ichneumon tribes dealing destruction to thousands of the larvæ—those insect pests which would otherwise work

terrible havoc with our corn crops and garden produce. On the other hand, it must be confessed that the larvæ of the sawflies often work damage to the foliage of forest trees, while in many tropical climates ants are a devouring scourge to all that belongs to man.

Classification We must now leave these introductory lines, but before passing on to a more or less detailed description of certain species and their peculiar characteristics of structure and of habit, the subjoined outline of classification of the various families of the order will give a general idea of the different groups, which are more obviously separated by certain broad distinguishing characteristics.

Order HYMENOPTERA

Suborder SESSILIVENTRES.
1. Family TENTHREDINIDÆ — Sawflies.
2. " SIRICIDÆ — Wood Borers.

Suborder PETIOLATA.

Section PARASITICA.
1. Family CYNIPIDÆ — Gall Wasps.
2. " PROCTOTRYPIDÆ — Egg Wasps.
3. " CHALCIDIDÆ — Parasitic Gall Wasps.
4. " ICHNEUMONIDÆ — Large Larvæ Wasps.
5. " BRACONIDÆ — Small Larvæ Wasps.
6. " EVANIIDÆ — Hymenoptera Parasites.
7. " CHRYSIDIDÆ — Burnished Wasps.

Section ACULEATA.
1. Family FORMICIDÆ — Social Ants.
2. " MUTILLIDÆ — Parasitic Ants.
3. " THYNNIDÆ — " "
4. " SCOLIIDÆ — " "
5. " SAPYGIDÆ — " "
6. " BEMBICIDÆ — " "
7. " POMPILIDÆ — Spider Wasps.
8. " SPHEGIDÆ — Locust Wasps.
9. " LARRIDÆ.
10. " NYSSONIDÆ.
11. " CRABRONIDÆ — Fly and Aphid Wasps.
12. " PHILANTHIDÆ — Andrena Parasites.
13. " MASARIDÆ — Solitary Wasps.
14. " EUMENIDÆ — Mud Wasps.
15. " VESPIDÆ — Paper Wasps.
16. " ANDRENIDÆ — Solitary Bees.
17. " APIDÆ — Honeybees and Humblebees.

The Sawfly Group — Suborder **Sessiliventres**

This group contains the various species of sawflies, and may be subdivided into the sawflies proper (*Tenthredinidæ*) and the wood borers, or tailed wasps (*Siricidæ*), although it also comprises the little pith-boring *Cephidæ* and the rare and little-known species of *Oryssidæ*. The food of the larvæ of these insects consists entirely of vegetable matter. In the case of the first-named family, the leaves of trees and shrubs; in that of the second, the solid wood of various trees; and in the case of the third, the tender pith of the stalks of rye and also the shoots of pear and other trees. Such grubs as are internal feeders are either limbless, or have at most six more or less rudimental thoracic legs. Those, on the other hand, which live a free life and feed on foliage, are very similar in general appearance to lepidopterous larvæ, from

1. *Sirex juvencus*, female larva, pupa (all of natural size); 2. Corn sawfly and larvæ in the rye stalks; 3. *Pachymerus calcitrator*, a wasp parasitic on the above; 4. Larva and pupa of *Cephus* (enlarged).

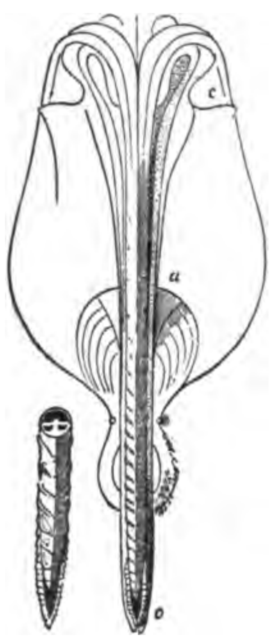
which they may be distinguished by the greater number of their legs; these varying from twenty to twenty-two, whereas those of the Lepidoptera have but sixteen at most. They also differ by the shining and almost naked skin, and the curious habit possessed by many of curling in the posterior segments, raising them at the same time and depressing them with a rhythmic movement. This action, which may be for the purpose of frightening away foes, coupled with the melancholy-looking eyes, gives them a grotesque appearance, not observable in the caterpillars of the Lepidoptera, save in a few instances. When full grown, the majority of the larvæ leave the food plant and spin in or on the surface of the ground, or under dry leaves and moss, a barrel-shaped cocoon in which they pass the winter, turning to a chrysalis only a short time before the perfect insect emerges. At least a thousand species are known, though this is probably but a small moiety of those that exist.

STEM SAWFLIES — Family *CEPHIDÆ*

The larvæ of these slender, delicate, armored insects pass their lives in the stems of plants or young shoots of trees; and the adults are characterized by the saw of the female being partially concealed by two integumental flaps. As an example of the typical genus, we may take the corn sawfly (*Cephus pygmæus*), of which the perfect insect flies actively in the sunshine, flitting from blossom to blossom among buttercups in May, and thence onward through the summer. The larvæ cause serious damage on the Continent to rye crops, and more rarely in wheat fields, where they crawl up and down within the stems, feeding on the delicate tissues. When full fed, they construct a transparent cocoon in which to pass the winter, becoming pupæ, and a little later in May emerging as full-grown sawflies. The parasitic insect (*Pachymerus calcitrator*) figured in the illustration on p. 2977 is one of the Petiolate Hymenoptera which seems to be exclusively parasitic on the present species.

TAILED WASPS — Family *SIRICIDÆ*

In this family the female is furnished with a long, boring ovipositor for piercing the bark of trees; the eggs being laid in the orifice thus formed, and the larvæ feeding on the wood. In the accompanying illustration of the boring apparatus of one species *c*, *c*, *a*, shows the whole of the muscular structure with which the boring is carried out. The perfect insects are usually of large size and conspicuously colored. Among the typical forms the common tailed wasp (*Sirex juvencus*) is a very rare species in England, although more plentiful on the Continent. The females, which are sometimes surprised in the act of depositing their eggs on pine trees, may be easily caught, as the ovipositor can only be withdrawn with considerable difficulty. Indeed, the abdomen breaks in half, if the insect be roughly grasped. The much larger giant-tailed wasp (*S. gigas*) is far commoner among pine trees, and is distinguished by its bands of black and yellow. Although it does considerable damage, it does not attack a perfectly healthy tree, unless recently felled. How long the larvæ may live in the interior of the tree, and how long it is before the perfect insect appears, is not known, but cases are often quoted of this insect appearing in houses soon after their completion, having evidently emerged from the wood of the joists and beams. Another genus is well represented by the broad-bodied sawfly (*Lyda campestris*). In this species the grubs feed on the young shoots of the Scotch fir, in which the eggs are laid. When hatched, the larvæ spin a slight web in which they remain concealed, protruding the fore part of the body

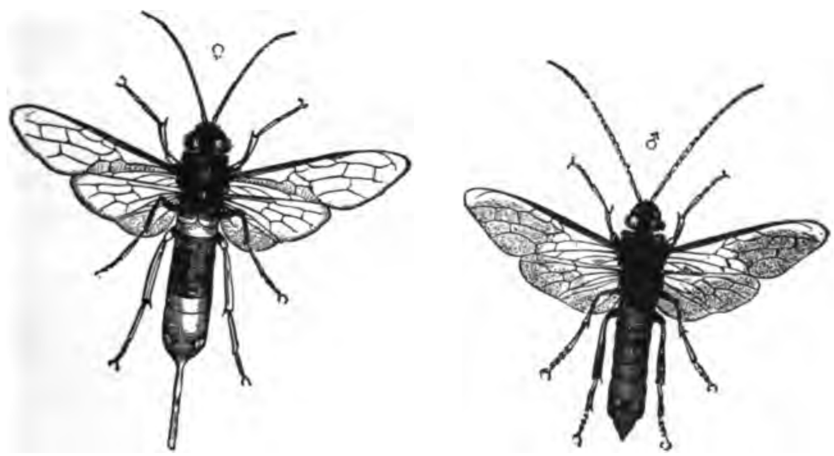


BORING APPARATUS OF GIANT-TAILED WASP.
(Much enlarged.)

when feeding on the pine needles. When all the needles in the neighborhood have been devoured, the web is extended, so that a great number of young shoots may be embraced and destroyed. The perfect insect is shining blue black, with some of the abdominal segments reddish yellow.

TRUE SAWFLIES—Family *TENTHREDINIDÆ*

In this exceedingly numerous and widely-distributed group, a well-known example is the pine sawfly (*Lophyrus pini*), of which the larvæ are sometimes found in such numbers in pine woods, where they feed upon the needles, that the trunks are often colored yellow and the branches weighed down. Toward the end of July, the perfect insect emerges by gnawing off the cap of the barrel-shaped pupa case. The eggs are laid in incisions made in the needles, these wounds being subsequently closed with a viscid secretion which protects the eggs. As many as twenty eggs may thus be deposited in a single needle. When young, and also just before turning into pupæ, the grubs are very susceptible to sudden cold or heavy rain, which will kill off thousands. In addition to these destructive agencies, nearly forty different kinds of parasites infest the grubs, while mice devour numbers of the pupæ.



FEMALE AND MALE OF GIANT-TAILED WASP.
(Natural size.)

The illustration below shows all the stages of development, one of the grubs being drawn in the act of endeavoring to ward off the attacks of a parasite by the ejection from its mouth of an offensive fluid. To the same family belongs the turnip sawfly (*Athalia spinarum*), which is one of the most destructive species. The perfect insect appears in May from larvæ which have passed the winter in their pupæ cases, and lays its eggs upon the leaves of rape and turnips; as many as two hundred or three hundred eggs being often deposited by a single female; and in September and October the ravages of the green and black larvæ become only too evident. The grub is full grown in October, when it descends to the surface of the earth, and

forms a cell of earth grains, in which it passes the winter. The majority of the members of the family belong to the typical genus *Tenthredo*, and are elegant, active insects, which alone of all the sawflies exhibit a carnivorous habit. It is not

1. PINE SAWFLY, larvæ on pine needles, and also papæ cases shut and open; 2. BROAD-BODIED SAWFLY, with larvæ and nest.
(All natural size.)

easy to distinguish the males from the females, though the difference in the color is of some assistance. It has been noticed, for instance, that in cases where the ab-

1. TURNIP SAWFLY AND LARVÆ; 2. ROSE SAWFLY, male: 3 SAWFLY, female, and with larvæ.
(Natural size.)

domen of the female is entirely black, that of the male is black and red. Of the green sawfly (*T. scalaris*), the larva is common on the willow, and is pale green

with black spots on the back, sometimes blending to form a central band. The pretty brush-horned rose sawfly (*Hylotoma rosæ*), which in size and color closely resembles the turnip sawfly, extends throughout Europe, where it is common wherever rose trees occur; the larva being found from July to October on both the wild and cultivated roses. When turning to a pupa, it spins an outer meshed envelope, and a more densely woven inner one; early larvæ pupating at once, and emerging as perfect insects early in August. The later broods, however, pass the winter in the pupa case, and appear in the following spring. The female makes an incision on the twigs of rose bushes, in which she lays her eggs, after which the twig withers away.

TYPICAL GROUP — SUBORDER **Petiolata**

The insects belonging to this second subdivision of the order are distinguishable from the last by the petiole, or short stalk joining the abdomen to the thorax. Sometimes this stalk is so short that the abdomen and thorax are closely united, while in others it is longer, and thus these characteristics form a fairly natural subdivision of the Petiolata into the pseudosessile and pedicellate forms. For general purposes they may, however, be divided into Parasitica, or those in which the females are furnished with an ovipositor, and Aculeata, or those in which the ovipositor has become modified into a retractile sting.

GALL WASPS — Family *CYNIPIDÆ*

Of the former, or parasitic section of the suborder, our first representatives are the gall wasps (*Cynipidæ*), all of which are small and inconspicuous insects, varying in color from black to brown and brownish red. The wings are furnished with

GREEN SAWFLY, *Tenthredo scalaris*.
(Natural size.)

few nervures, and the dark stigma on the anterior margin is absent; while in some species the females have the wings either rudimentary or altogether wanting. Of the galls so common on the foliage of trees and other plants, some are produced by

beetles, aphides, flies (gall midges), and others by the members of the present family and some of the *Tenthredinidæ*. In the gall wasps each species selects some

1. COMMON OAK GALL WASP; 2. *Torymus regius*, a parasite on the same; 3. Gall of *Cynips gemmæ*; 4. Larval chamber, shut and open; 5. The same enlarged, above on the left is figured the purple hairstreak and its larva; 6. The same enlarged; 7. A gall cut through, showing the grub.

1. THE SPONGE GALL WASP, with an old sponge gall; beneath is a new gall, whence the wasps have not yet made their exit; 2. OAK ROOT GALL WASP, with its gall; 3. BRAMBLE GALL WASP (*Diastrophus rubi*), with its gall; 4. A gall of the same slit in half; 5. *Synergus facialis*; 6. *Figites scutellaris*, parasites; 7. *Ibalia cultellator*, parasitic on *Sirex juvencus*. (All the galls and Fig. 7 natural size; Fig. 6 enlarged.)

special portion of the plant for its attack, which it pierces with its ovipositor, and lays an egg in the wound. As to what exactly gives rise to the resultant gall, which follows sooner or later upon the wounded plant, is not known with any certainty. It has hitherto been supposed that the fly injects an irritating fluid into the wound, but recent researches tend to show that this serves rather as an adhesive security to retain the egg on the selected spot. It is probable that the different stimulative irritants offered, first by the inflicted wound, next by the presence of the eggs, and thirdly by the movements of the larva after it is hatched, together with the action of a fluid exuded by the grub itself, all tend to produce the strange modifications of cell structure which manifest themselves in the forms of the various kinds of galls. The larvæ of the *Cynipidæ* almost entirely feed internally upon galls produced on oak leaves and the oak blossoms. These galls are entirely closed, and the grub dwells within a hard cell, called the larval chamber. In some cases there may be several such chambers, as, for instance, in the Bedeguar gall on the wild rose tree formed by *Rhodites rosæ*. We have said that each species confines itself to one portion of the plant, and the form of the gall is the same; but an exception is furnished by the galls of *Spathegaster baccarum*, which occur upon the leaves as well as on the flower tassels of the oak.

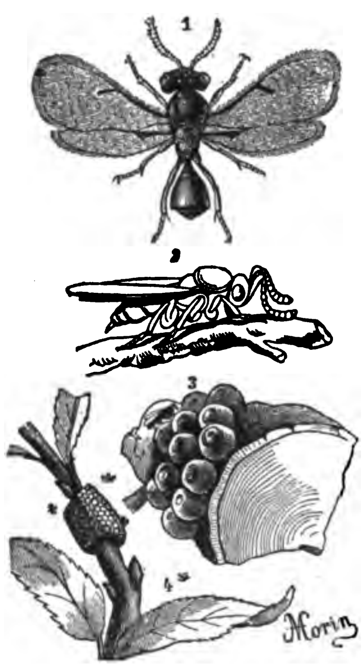
The phenomenon known as the alternation of generations,—that is to say, where produced generations alternate with each other in consecutive succession,—has been clearly shown to exist amongst the *Cynipidæ*. It is a remarkable fact, too, that the galls produced by a parthenogenetic female are different in form from those produced by a female originating from the normal sexual process. The insects produced by these different galls were for many years looked upon as distinct species. It is, of course, on the cell tissues of the gall that the larvæ of the *Cynipidæ* feed and thrive; they themselves, however, in their turn being subject to the attacks of numerous hymenopterous parasites of various kinds.

ROSE GALL WASP AND ITS GALL.

Of the typical genus, we may take the common oak gall wasp (*Cynips folii*) as a familiar example. It is a glistening black insect, which forms an oak gall on the under side of oak leaves. A parasite (*Torymus regius*) lays its own egg upon the larva of the *Cynips* lying within the gall, when the latter is about half grown. Another species (*Cynips gemmæ*), is produced from conical scale-covered galls, sprouting from the young shoots of the oak, in the interior of which the grubs feed. The illustration on p. 2982 shows the gall produced by insects of this species. To the same family belongs the sponge gall wasp (*Teras terminalis*), which emerges

from many-chambered spongy galls. In spring these galls are light colored; but later on, when the insect has made its escape, become brown. The female insects may be either winged or wingless, whereas the males are always provided with these appendages. Upward of forty parasites have been reared from the galls of this species. Yet another familiar type is the bramble gall wasp (*Diastrophus rubi*), which in spring produces hard and often twisted swellings on bramble stems, from which in due course emerge the perfect insects. In the same illustration is shown the oak root gall wasp (*Bioriza aptera*). In this form the female is wingless, but the male is unknown. The galls are formed on the rootlets of the oak trees beneath the surface of the ground.

In the common rose gall wasp (*Rhodites rosæ*), which produces the so-called bedeguan gall on roses, the larvæ are full fed in autumn, although the perfect insect does not appear till the following spring. Their beautiful, mossy, pink-tinted galls furnish a home for many other insects, such as various species of *Synergus*, but especially parasites belonging to the families *Pteromalidæ* and *Braconidæ*. *Synergus facialis*, of which a figure is given in the lower illustration on p. 2982, is parasitic on the gall wasps. So too is *Figites scutellaris*, shown in Fig. 6 of the same illustration. These are gall wasps, so far as structure is concerned; but as regards their habits they are in no way different from ichneumons, living in the larval state in the bodies of various insects. *Figites scutellaris*, as well as most other members of the group, are parasitic on the larvæ of the flies; while *Ibalia cultellator* is parasitic in the larvæ of the giant sawflies.



EGG WASPS.
1. *Teleas læviusculus*; 2. *Teleas terebrans*; 3. Eggs of a moth with a *Teleas* upon them about to pierce and lay its eggs within; 4. Eggs. (All but No. 4 much enlarged.)

Family *PROCTOTRYPIDÆ*

The members of this obscure family are minute insects, with scarcely a trace of nervures in the wings in some species; and the ovipositor can be protruded and withdrawn at pleasure. Though some of the species are wholly unlike the Aculeata, yet others approach them so nearly in general characteristics that the present classification must be regarded as tentative. The habits of these minute insects are imperfectly known, though some are parasitic in the eggs of insects and spiders. The perfect insects, small and black, with variously-shaped plumose wings, seem to prefer damp, dark localities, such as furnished beneath fallen leaves and débris of hedges. Here also may be placed the two species of egg wasps (*Teleas læviusculus* and *T. terebrans*), which are both shining black and very minute insects, shown in the accompanying illustration, where they are buzzing

round the eggs of a moth, ready to insert their own. The females usually deposit their eggs in those of the family *Bombycidæ*, as, for instance, those of the common lackey.

Family *CHALCIDIDÆ*

This group includes a large number of small brightly-colored insects with metallic lustre; nearly three thousand European species being known, while the tropics have not yet furnished their contingent of species. The antennæ are always elbowed, and the wings broad with few nervures. Some of the larvæ live in galls, devouring the grub of the gall wasp or those of the other inhabitants of the galls. The members of the present order, scale insects and plant lice, are alike subject to the attacks of the species of this family. One species (*Leucopsis gigas*) found in Southern Europe lays its eggs in the larvæ of a mason bee, which makes a cell of hard cement to protect its grub. Now the attacker has a boring apparatus, and the problem is how to ascertain the whereabouts of a grub, bore through the hard masonry, and lay eggs in the inmate. The cells are not distinct; but the whole

1 3 2

1. GOUTY-LEGGED WASP; 2. CHRYSALIS STINGER; 3. Sketches of various *Chalcididæ* (enlarged).

number, which are made in a sort of colony, are covered with cement, so that the task is doubly difficult. With the divining powers apparently situate in the antennæ, a suitable spot is chosen, and after, it may be, an hour or so of continuous boring, the succulent morsel is reached and the egg laid. How the wasp knows where the grub lies is not known. It seems to have the power — if not of seeing — at any rate of feeling literally through a brick wall. One of the largest members of the family is the gouty-legged wasp (*Smicra clavipes*), the egg of which is laid in the larvæ of certain water insects. The wasp is glistening black, with reddish legs, the wings being better furnished with nervures than in other members of the family. In the chrysalis stinger (*Pteromalus puparum*) the egg is laid in the chrysalis of several common butterflies during summer, while the larvæ remain in their host all through the winter, sometimes to the number of fifty.

The Ichneumon Wasps—Family *Ichneumonidæ*

The species included in this vast family number upward of six thousand, and doubtless more remain to be discovered. The majority are parasitic on the larvæ of Lepidoptera, rendering good service to the agriculturist and gardener by holding in check the enormous quantities of larvæ hatched every year. Some, however, attack other insects as well as spiders. The family is distinguished by the variation of the wings, though these characteristics vary too slightly to be of much value for generic or specific purposes. The antennæ are of uniform thickness, many jointed, and, as a rule, filiform, though in some exceptional cases club shaped. The ichneumon wasps do not hum, either when quiescent or on the wing, and are thus enabled to approach the victim within whose body they wish to lay their eggs with a greater chance of success. Having selected a suitable caterpillar, the female

1. *Exenterus marginatorius*, about to sting the larva of *Lophyrus pini;* 2. Pupa case of the latter with the parasite emerged; 8. With the proper sawfly emerged; 4. *Bassus albosignatus*, about to attack a Syrphus-larva; 6. *Banchus falcator;* 7. Pupa of the ichneumon.

(Natural size.)

deposits an egg with her ovipositor either on or beneath its skin. The egg soon hatches, and the grubs feed upon the tissues of the larvæ until full fed, when they pupate in or around the now almost empty skin of the caterpillar. The family has been divided into five groups, sufficiently distinguished from each other in their typical forms, but merging into one another through transitional species. Our first example is the ichneumon (*Exenterus marginatorius*) figured in the accompanying illustration, which belongs to the subfamily *Tryphoninæ*, and is found chiefly in pine woods, where it is parasitic on *Lophyrus pini*, described on p. 2978. The female attaches an egg by means of a hooklet to the skin of the green larvæ, when nearly full grown. When the insect forms its barrel-shaped pupa, in which to pass the winter, the parasite remains attached to the skin of the larva, whose tissues it

gradually absorbs. The perfect insect makes a small hole in the pupa case when it emerges, and does not, as does *L. pini*, bite off a little cap at the top. Another type is *Bassus albosignatus*, which frequents the honey dew dropped by aphid colonies. It lays its eggs on various larvæ which feed upon the aphides. In the allied genus *Banchus*, the species are parasitic on caterpillars, especially those of the hawk moths. The affected larvæ do not even reach the pupal state, but shrivel away, while the parasites form pupæ within the empty skin. The members of the typical genus and subfamily, such as *Ichneumon pisorius*, are among the largest and most brightly colored of the group; their colors, which are white, black, red, and yellow, occurring in great variety of combination. The females are usually more brightly colored than the males. The former sex is easily distinguished by the filiform antennæ, which are sometimes knotted, and may be observed to coil after the insect is dead. Many fine species may be taken from moss in the spring, where they

1. *Ichneumon pisorius*, male, and empty pupa of pine hawk moth, whence the parasite has emerged; 2. *Cryptus tarsoleucus*, male; 3. *Mesostenus gladiator*, female; 4. *Ephialtes manifestator*, male and female, the latter laying her eggs.

(Natural size.)

hibernate, though the great majority appear in the summer and do not live through the winter. The European species named is one of the largest, and may be regarded as typical of the general appearance of members of the family. It is found from June onward in pine woods, where it attacks the larvæ of the pine hawk moth, depositing a single egg in each victim. The caterpillar maintains its general health, and passes into the chrysalis state as though nothing were amiss; the only difference being that a large ichneumon fly emerges instead of the expected moth. An illustration of the parasite is given in the accompanying figure, together with a pupa case, with the cap removed, whence the fly has escaped. Of the other forms here figured, the male of *Cryptus tarsoleucus* gives a good idea of the general appearance of the males of the ichneumons, with their narrow elongate abdomen. All the species of *Cryptus* are parasitic on the larvæ of the sawflies, and the *Bombycidæ;* the female laying several eggs in each larva. A fine handsome form is one known

as *Mesostenus gladiator*, on account of its long needle-like ovipositor. It flies in June, and may be found in the vicinity of old crumbling walls, where bees of various kinds make their nests in the holes and crevices. In the same illustration is figured *Ephialtes manifestator*, representing the subfamily *Pimplariinæ*. In some members of this group the ovipositor issues from a ventral cleft in the abdomen, and in others from the tip itself; the instrument being sometimes three times the length of the entire body. All the species of the genus are much alike in general appearance, the smaller kinds being parasitic on small larvæ, and the larger on those of superior size. They may be seen flying about in woods in summer, in search of the wood-boring larvæ in whose bodies they lay their eggs. With intelligent agility the female hurries over the trunk, but by what sense she ultimately detects the presence of a larva within, and directs the ovipositor straight down to the spot, it is impossible to say; sight can be of no assistance, nor, one would judge, can touch. Can the antennæ be used, as the dividing rod is supposed to be used in the search for water, when common sense methods have failed? Possibly, however, the sense of smell assists, and thus the seemingly miraculous becomes once more a commonplace. The females apparently follow the borings of the larvæ, for it would be next to impossible for them to penetrate the hard fibres of the timber in which their victims burrow. One of the commonest members of the family, and one of the largest English forms, is *Pimpla instigator*, which preys upon many species of larvæ, especially those so destructive both in gardens and the forests. The perfect insect may be seen on tree trunks, in woods and hedgerows, searching for larvæ, with its wings raised, ready for instant action. The illustration represents this species attacking the larvæ of the satin moth.

Pimpla instigator. female to the left, stinging the larva of the satin moth. To the right is the moth, beneath it the pupa, from which emerges the adult, while the male of the parasite is seen below.

Family *BRACONIDÆ*

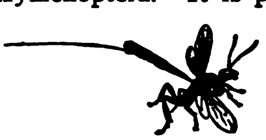
The members of this family are very similar in general appearance to those of the last, though the differences in the number and form of the cells inclosed by the wing nervures forms an easy distinction. In habits the *Braconidæ* are similar to the *Ichneumonidæ*, attacking as a rule the larvæ of Lepidoptera, although they are found as well in those of other insects. Upward of a thousand parasitic grubs of the genus *Microgaster* have been taken from a single caterpillar. It must be remembered that the grubs are not in reality gnawing at the vitals, but are nourished by the fluids circulating through the system. As an example of the family, we may

take the genus *Microgaster*, which comprises many of the commonest species. The females of all, except two which are parasitic on *Aphides* and the egg of spiders, attack the larvæ of Lepidoptera, especially those clothed with hair. They are themselves the victims of the attacks of a species of *Pteromalus*—a genus of Hymenoptera briefly noted above.

Microgaster nemorum, female (enlarged); its larvæ are feeding upon a large caterpillar (these of the natural size).

OTHER FAMILIES

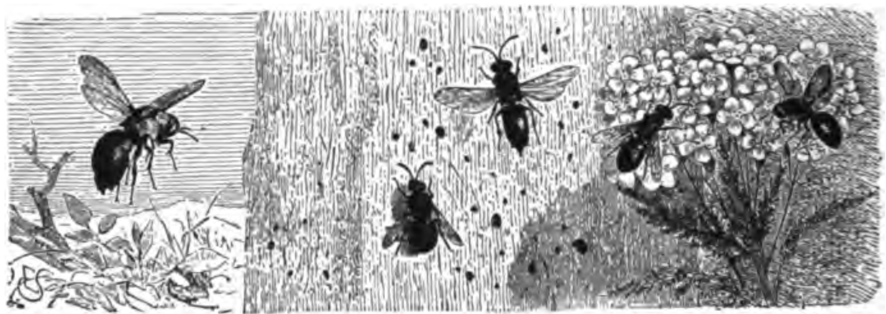
In the family *Evaniidæ* the abdomen is attached above the middle of the metanotum, not to its lower margin. Among these is the javelin wasp (*Fœnus jaculator*), a species parasitical on Hymenoptera which breed in old walls. In the typical genus *Evania* the species are believed to be parasitic on the cockroach, depositing their eggs in the egg capsules, and this habit will account for the presence of a certain species on board ships, where cockroaches abound. The members of the family *Chrysididæ* are not easily mistaken for those of any other, being of moderate size, and distinguished by the brilliancy of their color, not only in the tropics but even in temperate climates. The integuments are more or less coarsely punctured, and the whole body glistens with metallic lustre, golden yellow, fiery red, blue, and green, all these being as a rule in combination. The perfect insects are most numerous in the summer months, and may be observed among flowers, on decaying timber, old walls, and other suitable hunting grounds. The females lay their eggs in the nests of the various burrowing Hymenoptera. It is probable that the grub devours the store of food garnered for its own progeny by the careful mother. Possibly it makes little distinction between the food supply and the tissues of the organism nournished by them. The common ruby-tailed wasps belong to this family.



JAVELIN WASP, *Fœnus jaculator*. (Natural size.)

The golden burnished wasp (*Stilbum splendidum*) is entirely steel blue or golden green. It occurs on the shores of the Mediterranean, and is also found in Asia. It is one of the largest of the European forms. Among these, the burnished blue wasp (*Chrysis cyanea*) is universally distributed throughout the whole of Europe. The females lay their eggs in the larvæ of those species of Hymenoptera which make their nests in bramble stems. The common golden wasp (*C. ignita*) may be seen flying in search for the larvæ of Hymenoptera, whose burrows are made in old posts, walls, sand pits, and other such places. Of the royal gold wasp (*Hedychrum lucidulum*), another of the commoner and more beautiful species, a

figure appears in the accompanying illustration. In the same illustration is also shown the brazen-tailed wasp (*Elampus æneus*), of which the female deposits her eggs in the grub of a small species of the *Sphegidæ*.



BURNISHED AND GOLD WASPS.
1. Golden burnished wasp; 2. Burnished blue wasp; 3. Common golden wasp; 4. Royal gold wasp, female; 5. Brazen-tailed wasp.

The Ants — Family *FORMICIDÆ*

The ants bring us to the section Aculeata, the members of which differ from the preceding section in that the females are furnished with a retractile sting in place of an ovipositor. As a family, ants are characterized by having the first segment of the abdomen and sometimes also the second reduced in size to form a stalk for the rest of the abdomen. The workers, moreover, are without wings. On account of their remarkable habits and intelligence, these insects demand a fuller notice than is accorded to other groups. As regards their visual powers, ants are very sensitive. While disliking any strong light suddenly thrown into their nests, they prefer rays transmitted through a red medium, but object more to those coming through green and yellow, while those through a violet medium they abhor. Though sight is well developed, hearing seems much less so; vibrations of the air produced by tuning forks, violin strings, or whistling, being little heeded. Neither has any sound emitted by the ants themselves been detected, even with the most sensitive instruments. The sense of smell is evidently keen, for brushes dipped in scent arouse distinct curiosity. When the scent left in its tract by an ant is obliterated, the ants next following are baffled, like hounds at fault, until, after a little casting about, they pick it up on the other side. In seeking for an object of whose existence and position they are aware, ants make use of both sight and smell; but it is in the latter that they place most confidence, for if the object be removed only the space of an inch from its position, the ant in search of it will make a number of cross journeys over the old resting place before it is successful. The scent, too, seems to be rather that left by former footsteps than proceeding from the object itself. This sense of smell, and perhaps touch combined, is obviously manifested in the caressing or recognition of friends with the delicate antennæ. The mysterious sense of direction is, after all, but sensitiveness to the direction in which the rays of light fall from a luminous object, and, as such, is but a form of sight. This is proved as follows: Ants made to cross

a wooden bridge would, in most cases, instantly turn round, if their heads were turned in an opposite direction, by the bridge being made to rotate on a point. And they would at once lose the sense of direction if light was shut out from the artificial tract prepared for them, while if the candle were moved round in the same direction as the bridge over which they traveled, though the direction be changed, the ant does not become aware of it, because the rays of light fall from the same point. Nevertheless, the sense of smell is evidently the stronger, for ants carrying larvæ from a cup to the nest still continue their course, although the board on which they are traveling be turned right round. They follow the scent of former tracks rather than take notice of the direction in which the light falls.

It is obvious that without some faculty representing, at any rate, the rudiments of memory, ants would not be able to recognize even the scent left by comrades on the ground, nor would they persistently seek for an object which had been removed. They exhibit, however, all the phenomena of true memory. A fact, by repetition, becomes more firmly fixed as a sense impression on their brains. It fades away if not refreshed. Evidence in favor of a highly-developed sense of memory is furnished by the fact that ants from a certain nest were in the habit of journeying year by year, during the season of activity, to a chemist's shop, six hundred yards distant, to a syrup jar. It is scarcely likely that the jar was found every year by fresh ants, so that memory alone will account for the circumstance. It is perhaps in the recognition of friends, however, that ants manifest the most extraordinary powers of memory. They invariably recognize a friend, while a stranger is almost instantly slain. Ants held captive for months, and returned to the nest, are recognized as lost friends, and caressed with the antennæ. This recognition might be merely a matter of the well-known odor of a friend; but even then it must be a national smell, for it is scarcely possible that each can recognize the personal scent of every individual. Not only do they recognize the perfect ants, but even the offspring, or eggs, removed and hatched in other nests, and returned home full grown, are recognized as kith and kin, while their foster mothers are slain. One can hardly suppose that the scent, unless such be inherited, would account for such recognition.

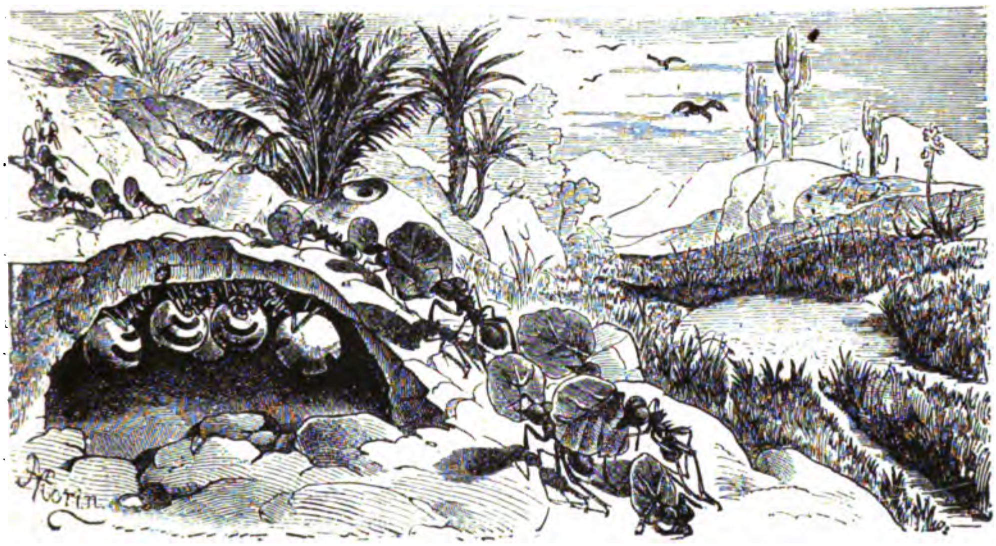
Whereas ants show evidence of such feelings as rage and combativeness, the emotion of sympathy is by no means as constant or intense as might be supposed from their general intelligence and power of recognizing friends. Mutilated ants, and those in difficulties, are passed by on the other side; but an intoxicated ant staggering in its tracks does not fail to excite astonishment, and is carried off as a sort of curiosity to the nest. Chloroform ants, however, are dropped into the water, where they were, of course, motionless. That ants have the power of communicating intelligence admits of no doubt. Two ants were introduced, the one to three hundred or six hundred larvæ in one glass, the other to two or three in another glass, each took a larva and returned to the nest. A larva was added to the second glass every time one was taken. In forty-seven and a half hours the ant which was introduced to the six hundred larvæ had brought two hundred and fifty-seven friends to help, while the other in fifty-three hours had brought but eighty-two.

The swarms of ants which in spring rise in clouds are males and females. This is their nuptial dance, and for hours they circle and sport in the sunshine. The males fall and die, or are destroyed by numerous foes. Nor is any assistance offered them by the workers, who well know that their vocation in life has been fulfilled, and they themselves are no longer of any use. The females having divested themselves of their wings, with claws and legs, set about founding new colonies. The eggs, however, must be nursed if they are to hatch, and are subjected to much licking by the nurses. Then the larvæ must be fed; next, they are carefully cleansed and carried for their daily walk through the lanes of the nest. Not even after the grub has become a pupa is the ant allowed to emerge without assistance. Büchner writes that "the little creature when freed from its chrysalis is still covered with a thin skin, like a little shirt, which has to be pulled off. When we see how neatly and gently this is done, and how the tiny creature is then washed, brushed, and fed, we are involuntarily reminded of the nursing of human babies." Next, they are taught their domestic duties, and to distinguish between friend and foe. If the nest is attacked, the older and more experienced fight, while the younger members remove the pupæ to a place of safety.

Ants not only feed upon the honey dew dropped by plant lice upon leaves, but also rear aphide eggs, and feed the insects for the sake of their secretion. Tunnels, or covered ways, are made by some ants up the branches of the trees where the aphides live, so that the insects are inclosed and kept prisoners. Certain portions of the tunnels are enlarged to form stables, where the aphides are penned, the doors being large enough for the narrow ants to enter and leave, but not for the rotund plant lice to escape. The "cows" are induced to part with a drop of honey dew by a gentle stroking with the antennæ, and general encouragement of other kinds. Ants are far in advance of human dairymaids in the matter of tact in dealing with their cows. Colonies of aphides have been carried by ants to fresh pastures.

It is no long step from cow keeping to slave making. At least three species of ants indulge in this reprehensible practice. A raid is organized against a neighboring nest — warriors and workers are slain, and the pupæ carried off, hatched and reared, soon to work and fight for their masters in the land of their captivity. In come cases the slaves are kept for indoor occupation, and are carried off as part of their goods and chattels, by their masters, when they migrate into new quarters. Another species does not work at all, neither males nor females; the workers — sterile females — capture slaves, but do no more. They neither feed their young, nor make their nests, — a city state entirely dependent on slave labor. Not only, however, do slave-making ants engage in expeditions against other communities for the purpose of securing servants; but even many ants, whose energies are confined to agriculture, not infrequently wage war for the sake of plunder on others whose habits of life are similar. An expedition of the former tribes usually consists of a general attack upon the nest of a species which they are in the habit of enslaving. Single scouts are sent out to reconnoitre, whose business it is to investigate the position of the nest and the whereabouts of the entrances. Having satisfied themselves of the feasibility of an attack, they return to their own nest,

and summon forth the hosts of ferocious warriors. These encouraging one another with taps of the antennæ, march on the unhappy colony, whose baby inhabitants they propose to enslave. Of all the warriors the most warlike are the amazons (*Formica rufescens*), robber ants of great size, strength, and courage. A column is formed, and, guided by the scent of their prey, as they come within the radius of their victims' pathways to and from their city, in hundreds they rush onward. An hour, it may be, after the start, the nest is reached and entered, and soon the struggle becomes a furious battle, on the one hand to save, on the other to carry off the larvæ. Up the neighboring trees the owners fly with their precious burdens, a harbor of refuge, secure from danger, for here the Amazons cannot follow — specialized to kill but not to climb. Others hang on the flanks of the retreating columns and harass the thieves bearing off the tender pupæ. A nurse seizes one



1. Honey-pot ants; 2. Parasol ants on the march; 3. Dwellings of husbandmen ants,
(Natural size.)

end of her nursling, the Amazon has the other, imperceptibly the jaws of the latter steal up, still holding on, toward the far end, till the nurse's head is pierced. Sometimes the Amazon lets go, and the nurse is gone in a trice, and the pupa with her, while the warrior contents itself with a vicious grin as the embryo slave vanishes into the tree tops. The slaves left behind in the city are ready to receive the plunder; and soon more slaves are hatched, whose prison is now their home, for they have never been conscious of another. But success does not always smile upon their expeditions; an entire army may lose the way, courage may fail the leaders, disputes may arise, and general unaccountable want of *esprit de corps* breaks their resolution, and the attack is abandoned. Many a warrior loses its way emerging from the ravaged nest by passages which open to the thicket far from those they entered by. The sense of smell is of no avail, that of direction does not rise to the occasion.

Another robber ant (*Formica sanguinea*), not so well furnished with offensive weapons, but larger and more intelligent than the former, also sallies forth in search of slaves. Both may meet in combat on the march, and the dead and dying mangled remains, and heads and legs nipped off, bear witness to the consequences. These robber ants do not attack a nest with a rush, as do the Amazons. They lay deliberate siege to it, surround it, securing the entrances and exits. None of the inhabitants are allowed to pass if they carry pupæ.

Of the other inmates of ants' nests such as beetles, crickets, spiders, wood lice, and the like, want of space forbids mention, and, indeed, the reason of their presence is not obvious. The supposition that they are kept as pets possibly derives support merely from the analogy drawn from similar whims among human beings. That ants sleep is an undoubted fact, and so too that they bestow much care upon their toilet, assisting each other in this respect. Bates writes that "here and there an ant was seen stretching forth first one leg and then another, to be brushed and washed by one or more of its comrades, who performed the task by passing the limb between the jaws and tongue, finishing off by giving the antennæ a friendly wipe." Recreations, too, are not unknown to them; running after each other in hide-and-seek, followed often by a rough-and-tumble game. Stranger still, they hide away the dead bodies of their friends in chinks and crevices far from the nest, and thus perform a sort of burial. That the habit is more than the desire to be rid of what is useless, or may be injurious, seems doubtful; unless, indeed, such device lies at the root of all funeral customs, as is not improbable.

Of the British species, the largest is the red wood ant (*F. rufa*). It abounds in fir plantations in the southern counties of England, and the huge heaps of pine needles it gathers over its nest are familiar objects to frequenters of the forests; while the size, ferocity, and numbers of the ants themselves become a nuisance even before their ways have ceased to be amusing. If the nest be disturbed, the fumes of formic acid burst out full in the face of the intruder, while the jaws of the enraged inhabitants render further operations impossible. Numbers of nests, however, are annually ransacked of their pupæ for young pheasants, which often seem surprised by the flavor of the ants, which they pick up with the pupæ. Highways cross the paths in every direction around the nest, and the ants may be seen coming and going continuously throughout the day, bringing in twigs, caterpillars, and fragments of all kinds of insects, to be safely stored away in the nest. Still larger is the Hercules ant (*Camponotus herculeanus*), which inhabits wooded highlands in continental Europe, and constructs its nest in decayed tree trunks. The female measures more than half an inch in length; and the insects, when swarming, gather in a cloud around the base of some tree. In color the body is glistening gray, while the tips of the wings are yellow. The honey-pot ant (*Myrmecocystus mexicanus*), of which the habits are alluded to above, inhabits the highlands of Mexico and South Colorado. The nest is constructed in the ground, usually beneath hillocks, in a gravelly soil, and contains passages and chambers arranged in different stories, some for food, others for the larvæ, and the third for the honey pots. The inhabitants condemned to servitude in the honey-secreting department of this community are never allowed out. An allied species is found in Australia. Still more

curious is the South-American saüba or parasol ant (*Œcodoma cephalotes*), dreaded on account of the havoc it works among the foliage of plantations. Agriculture, too, becomes next to impossible where these destructive insects abound. They are not without their uses, however, for the Indians regard the females when full of eggs as a delicacy. Seizing the insects by the thorax, they nip off the luscious morsel with their teeth, much as we may see monkeys behave toward a fly. The nests of this species are prodigious. Bates speaks of hills forty yards in circumference, or about twelve yards across, while others are of even larger size. This hill, huge as it is, is merely the outer covering of a network of galleries extending deep and far into the ground, with many outlets into the surrounding country, usually carefully secured. The workers, of which there are two forms, look after the progeny and gather food; while the soldiers, with broad heads and terrible jaws, sally forth if danger threatens their citadel. The stronger workers march in daily procession to the plantations in search of leaves, and return, each with a piece securely held in its jaws. The more slightly built remain at home, engaged in the less arduous operations of domestic economy, and rarely venture far from their nest. These leaf-cutting expeditions are directed chiefly against coffee and orange plantations, and the ants, accompanied by a detachment of soldiers, partly no doubt to keep order, and more especially to guard the caravan against freebooters, march in large columns to the groves, climb the trees, and begin to reap their daily harvest. Each ant having cut with its toothed mandibles a piece of leaf half an inch in diameter, descends the tree, holds its booty high in the air, edge upward, and so homeward. The leaf discs thus held above their heads have earned for these insects the name of "parasol ants." The path they travel on is soon beaten down with footsteps, and worn till it becomes a deep groove; but even height does not end their activity and mischief, for they make raids on the houses of the planters in search of groceries and sweet stuffs, appearing often in swarms. There are several species of this genus with similar habits, and all are known by the natives of Brazil under the single name saüba. An illustration of one of the leaf-cutting expeditions returning homeward is given in the illustration on p. 2993.

Family *MUTILLIDÆ*, etc.

This species included in the families *Mutillidæ*, *Thynnidæ*, and *Scolidæ*, number from twelve hundred to fifteen hundred. The females of members of the first two are wingless, while those of all three families possess a formidable poison sting. Of the European *Mutilla europæa*, the males may be seen, though not commonly, among flowers, and frequenting foliage infested with aphides. The wingless female may, however, often be met with on sandy commons in summer. The larvæ are found in the nests of humblebees, where they feed upon the grubs. All species of the family, however, are not parasitic on humblebees, for in South America, where the tribes of the former are scantily represented, those of the latter are numerous. Of the third family, we take as example the formidable *Scolia nemorrhoidalis*, which

is found in Turkey, Hungary, Greece, and Southern Russia. Not very much is known of its habits and life history, but such as is points to a larval life parasitic on various beetles; while other members of the family have been taken from nests of

Mutilla europæa—1. Female; 2. Male; and *Scolia nemorrhoidalis*—3. Male; 4. Female.

the parasol ant. In the *Scolidæ* the wings are present in both sexes. Figures of the male and female are given in the illustration above.

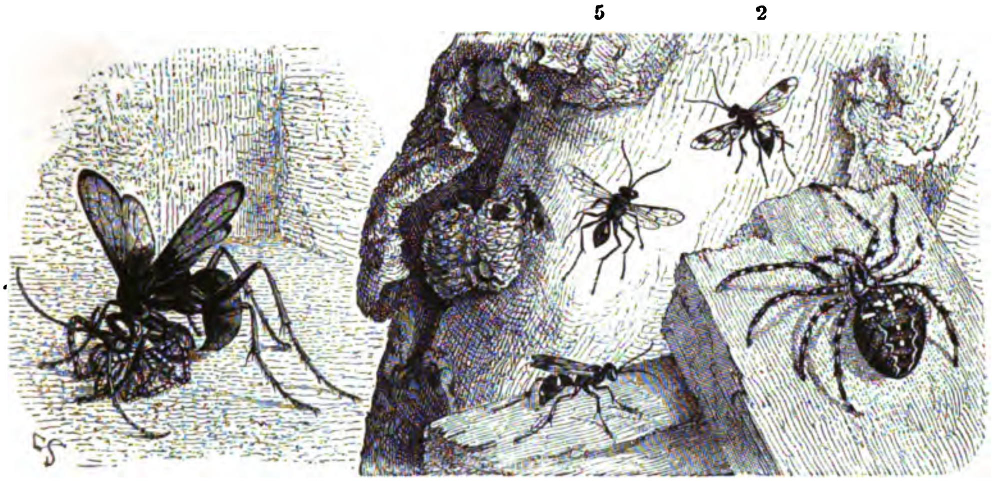
Family *BEMBICIDÆ*

The members of this family are distinguished from the *Sphegidæ*, mentioned on p. 2997, by the formation of the labrum, which is much produced. In general appearance they resemble the hornets and larger wasps. *Bembex rostrata*, figured on p. 2998, is found not uncommonly throughout Europe, but becomes more local in the northern countries. The insects fly in circles, with a loud hum of their powerful wings round and round the burrows which the female makes in the loose sand or earth. Here are stowed away the bodies of large flies, reduced by an application of the sting to a state of unconsciousness; and in each nest a single egg is laid, the grub when hatched feeding upon the food which it finds placed within its reach.

Family *POMPILIDÆ*

In this group the males are characterized by their slender form and small size; and both sexes may be recognized by their energetic hurrying to and fro with quivering wings and antennæ, moving rapidly on all sides as they search sandy commons for a suitable spot to burrow in, as well as for the spiders which they numb with a sting and store up for the larvæ. The members of the family are universally distributed, being larger and more brilliant in tropical countries. Some make their

nests in the beetle borings of old trees and posts, and prey upon all kinds of insects and their larvæ; others prey exclusively on spiders, and confine their burrowing operations to sandy soils. Not only do spiders of the family *Lycosidæ*, which run freely on the surface of the ground but make no nest, fall victims to the *Pompilus*, but the *Epeiridæ* are snatched from the very centre of their maze and carried off, their powers of resistance rendered futile by one paralyzing stroke of the poisonous sting. Well are these spiders aware of the danger, for they drop instantly from their webs into the herbage when the hum of wings warns them the near presence of a wasp. Others, however, whose staple food consists of bees and wasps, are not



1. *Pompilus natalensis;* 2. *Pompilus trivialis;* 3. Larva of latter on garden spider; 4. *Priocnemis variegatus;* 5. *Agenia punctum*, with its two cells.

so easily alarmed, and learn to distinguish between friends and foes. The figured *Pompilus natalensis* is of considerable service in Natal, since its habit is to search every nook and cranny for house-frequenting spiders. Up and down the windows, in and out among the rafters, the female passes to and fro in search of the large spiders which lodge in their webs hung up among the woodwork. The victims when captured are buried with the egg in a hole in some suitable corner within or without the house. A large species of this genus attacks spiders of the genus *Lycosa* on English commons, and buries them in a somewhat similar fashion. The second species figured in the illustration (*P. trivialis*) also attacks spiders, especially *Lycosa inquilina*.

Family *SPHEGIDÆ*

Many of the handsome insects belonging to this family are uniformly black, black and red, or yellow and black. The majority, however, are black with brilliant yellow or white markings, and shine with the lustre of burnished metal. These

markings are very variable even in the same species, rendering their identification difficult for the student, though on account of that contrast of color, and the activity of their movements, the members of this family are among the most attractive of all hymenopterous insects. Some species prey upon lepidopterous larvæ, others on grasshoppers, while another provisions its nest with three or four crickets. These latter, however, are not captured without a severe tussle. The *Sphex* leaps upon the cricket's back, delivers a couple of stings, and all is over.

Family *CRABRONIDÆ*

The numerous members of this family are usually black with yellow markings. Their nests are formed either in the ground or in decaying timber; the tunnels of wood-boring beetles being utilized in the latter case. While the smaller species feed chiefly on aphides, the larger kinds are more partial to flies. Figures of three species, *viz.*, *Crossocerus scutatus*, *C. elongatulus*, and *Crabro patellatus*, are given in the annexed illustration. Another form is *Mellinus arvensis*, usually met

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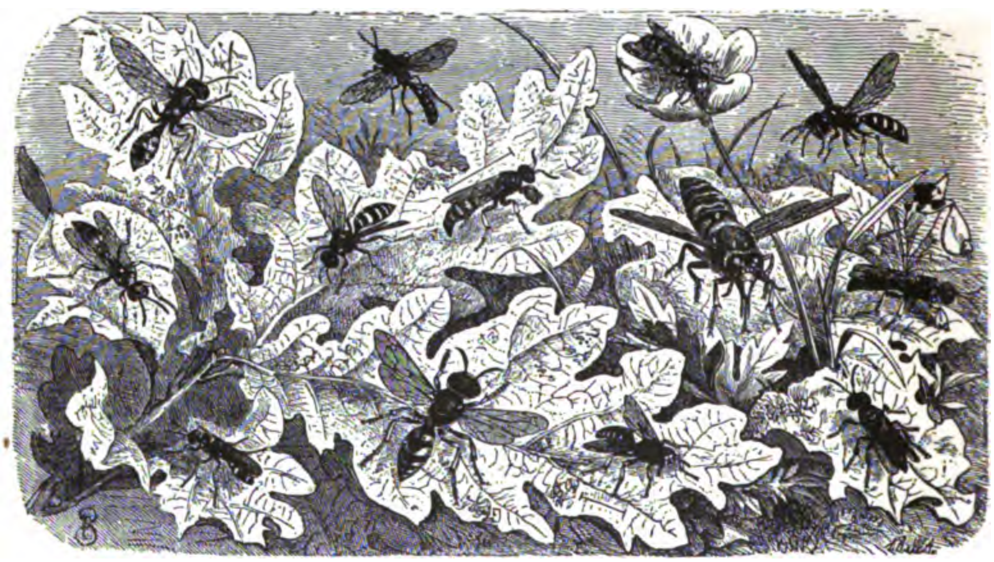


3 5 13 4 12

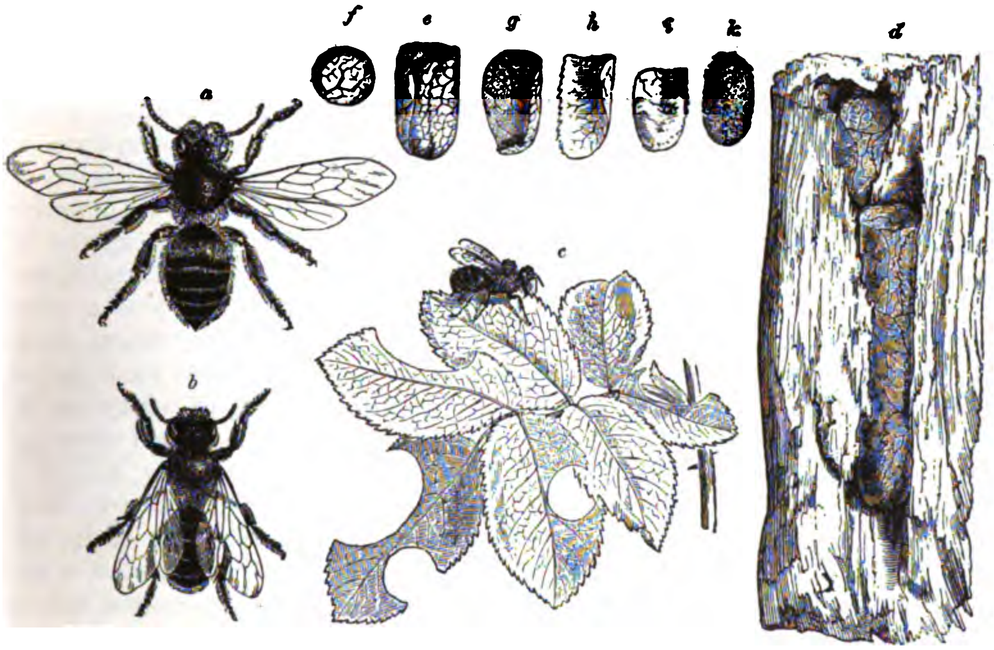
Mellinus arvensis—1. Male; 2. Female; 3. *M. sabulosus;* 4. *Bembex rostrata;* 5. *Philanthus triangulum*, *Cerceris arcuaria;* 6. Male; 7. Female; 8. *Trypoxylon figulus;* 9. *Crabro patellatus*—Female; 10. Male; 11. *Crossocerus scutatus*—Male; 12. *C. elongatulus;* 13. *Oxybelus uniglumis.* (1, 10–13 enlarged, the rest natural size.)

with in pine woods, where it may be seen searching about on the sandy soil, and is particularly fond of the honeydew deposited by aphides. A smaller form (*M. sabulosus*) is likewise shown in the illustration. The same illustration also shows *Trypoxylon figulus*, a black insect, which may be odserved throughout the summer flying busily to and fro among posts and decaying trees. A variation

in the mode of making its cell will be noticeable. Selecting a long tunnel, the female brings in aphides or small spiders, lays an egg, deposits a suitable supply of food, and fits on the top a wad of mud, above this again another cell is constructed, similarly capped with mud, and so on till the tunnel is full.

Family *PHILANTHIDÆ*

As an example of this family may be taken *Philanthus triangulum*, the larva of which feeds upon the honeybee, and other members of the same group. In the illustration on p. 2998 a figure of this species is given. Since, at least, five bees are provided for each larva, the havoc caused in hives where these insects abound must be considerable. A separated nest, in some warm sunny slope, is made for each egg. Another form is *Oxybelus uniglumis*, figured in the illustra-



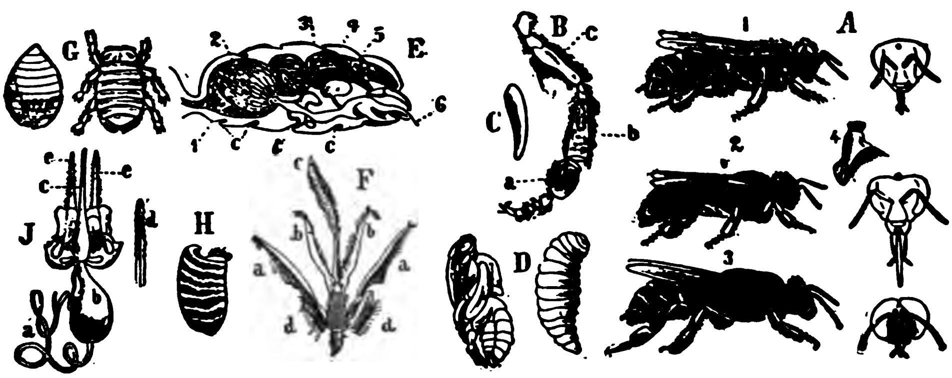
COMMON LEAF-CUTTER BEE. *a. b.* Female and male (enlarged); *c.* Rose leaves with several pieces clipped out and a bee at work; *d.* Nest in a willow stem; *e.* A single cell; *f.* The lid of same; *g-h.* Pieces of leaf; *i-k.* Side pieces.

tion on p. 2998. In this species the female excavates tunnels in sandy ground, to which the sunshine has free access, and flies are mainly used to provision the nest, as a rule one only to each cell. The fly is attacked from above, knocked down, stung in the neck, and carried off to the nest. A third form (*Cerceris arcuaria*), shown in the same illustration, is a black insect with yellow bands on the abdomen, as are most of its kindred.

Wasps and Bees

Before taking into consideration the families into which these groups are divided, it is advisable to give an account of some points connected with their habits, as well as a notice of their special senses. As regards sight, the large size of their compound eyes, in addition to the presence of ocelli, indicates their high degree of visual power. In respect of perception of colors, experiments have shown that if honey be placed on cards of different color, bees show a decided preference for special tints; orange and yellow being the prime favorites. Similarly, no doubt, the colors of flowers have a greater or smaller degree of attraction for these insects. Indeed, it is beyond question that the fertilization of flowers by the visitation of bees has tended to the development of the special colors patronized by the insects, while blossoms which were of less favorite hues have gradually disappeared. Black, white, and green flowers are not so common as yellow, orange, blue, or red; and black is less prevalent than either of the others. Although experiments to prove or disprove the sensibility of bees to sound have so far been negative, yet from the fact that they are exceedingly sensitive to a certain peculiar cry occasionally emitted by the queen, which acts like an electric shock, it would appear that hearing is likewise well developed. That bees and wasps are able to find their way, and to fly off apparently without hesitation straight for home, needs no proof. But this power does not necessarily indicate some mysterious sense of direction, enabling them to perceive their bearings by occult means. Rather may it be looked upon as due to the ordinary observance of conspicuous landmarks, such as are utilized for guidance even by man himself. Bees, for instance, have been taught the way to a store of honey by the repetition of single experiences, proving that they pass from the unaccustomed to the well known, little by little. Naturally, the direction of a point to which whithersoever they may wander out, they must invariably return many times a day, soon passes from the sphere of calculation and enters the region of simple intuition; so rapid and unconscious are the various acts of perception involved. That these insects do thus take note of landmarks has been shown by Bates, who describes how a sand wasp carefully marked the spot where half of a larva had been left by circling round and alighting in the vicinity. And even then, when it returned, though it flew many times straight to a certain conspicuous leaf close above the booty, doubtless a landmark, yet it could not for a long while — and after repeated pounces in the wrong direction, and more it seemed by good luck at last — succeed in finding it. No one who has heard the cry of an angry wasp, and experienced the pain which has followed, will doubt that anger and malice have their places in the wasp's nature. Often do these insects seem to make straight for an innocent bystander, and sting from pure spitefulness. Sympathy for the ailing and wounded, as among the ants, so among the bees, seems to be more noticeable than it is toward those actually in distress,— though uninjured. It has been doubted, indeed, whether bees show any affection for one another; the caressing antennæ, as well as the personal attentions to each other so noticeable in the case of ants, are certainly lacking. As in ants, however, the antennæ seem to be the chief organs of communication.

As regards habits, there are two chief operations in which bees and wasps engage, namely, the procuring of food and the rearing of a progeny. This food is of two kinds,— honey gathered from the nectaries of flowers, and bee bread, or flower pollen moistened with honey, kneaded by the workers, and stored away, for feeding the larvæ. The workers, or honey gatherers, do not bring in more than one sort of pollen at the same time; and when the nurses, or domestic bees, receive the pollen from the honey gatherers they keep it carefully separate. This sort of pollen is more nutritious than another, and a female larva fed on the more nutritious bee bread will become a queen or fertile female, and one hive cannot afford more than a few of such luxuries. Those fed on the less nutritious bread turn out workers, or nonfertile females. For the males special conditions are arranged by the queen when laying the eggs. Royal cells, framed for the feeding of queens, are much larger than those for workers. In secreting wax for the cells, bees hav-



INMATES OF A HIVE.

A — 1. Queen; 2. Worker (nonfertile female); 3. Drone or male; 4. Mandible from outside. (All slightly enlarged.) B. Hind leg of worker; *c*. Thigh (*femur*); *b*. Shank (*tibia*); *a*. First tarsal joint. C. Egg (much enlarged). D. Larva and pupa (natural size). E. Longitudinal section of the abdomen of a worker; 1. Honey crop; 2. Egg sac; 3. Poison sac; 4. Oil gland; 5. Semen sac or spermatheca; 6. Sting; *c*. Segmental interstices, whence the wax issues. F. Mouth parts; *a*. Maxillæ; *d*. Basal joint of same; *b*. Labial palpi; *c*. Tongue. G. Bee louse and its pupa (much enlarged). H. Brush (much enlarged). J. Poison apparatus; *a*. Poison gland; *b*. Poison vesicle; *c*. Sting groove; *a*. Sting; *e*. Sting sheath. (All much enlarged.)

ing eaten as much honey as they can conveniently carry, hang in a cluster from the top of the hive. Soon the wax begins to burst from glands beneath the edges of the segments of the body, and is rubbed off with the legs. Cell construction now begins, and in addition to the wax, a sort of resinous cement, drawn from the sap of conifers, is used to strengthen the walls at their angles, and also to cover the inside of the hive.

Honeybee

The six-sided form of the cells of the honeybee appears to have been evolved after ages of gradual modification from the simple cylinder which would be formed by a cylindrical body — as that of a bee — molding wax around itself; this form alone admitting of the greatest number of cells being placed side by side, and tier by tier, without leaving waste vacant spaces between. The greater the number of the cells the stronger the color, the stronger the color the more numerous the swarms and the greater the chance of the perpetuation of the race. The intermediate form between the cylinder and the

regular hexagon is found in the comb of the Melipona bee, which forms cylindrical cells, but so close together that the partition wall becomes a flat plate, since it is impossible for a thin sheet to be concave on both sides at once; modifications from this form combined with modified instincts would eventually produce a regular hexagon. It is to be borne in mind, however, that this form arises not because the bees are aware that a regular hexagon is the most economic form of cell they can adopt, but simply because, when a group of bees stand close to each other, and form cells of pliant wax,—whose walls break through at all points on account of their proximity, rendering it necessary to build up a flat wall between,—they cannot fashion it in any other way. For at all points of a single cell, six bees at the sides, and six bees below are constantly encroaching and fitting in the sides and corners of their own cells, around that of each single bee. Bees have proved in practice what to the mathematicians is inevitable in theory. Nevertheless, bees are not compelled to form their combs in this or that way without any power of adaptation to special circumstances. They construct their comb and hang their connections wherever the holding seems likely to be most secure, and thus, on a less complicated plane of intelligence, carry out precisely what human beings accomplish under more complex conditions, namely, they adapt means to ends. The difference is one of degree, not of kind.

The fact that eggs are laid by a single female of unusual size is noteworthy. Bee colonies, however, unlike those of the social wasps, are permanent, hibernating during the winter. Each wasp colony or nest originates from a single female, which survives through the winter and by herself lays the foundation of a new colony. Among bees a certain number of workers, or nonfertile females, are set apart as maids-in-waiting, who attend to the queen's wants in the matter of food, which are considerable during the period of laying. A single egg is laid in each cell, and, as mentioned before, larger cells are set apart for the queens; the difference between these and the nonfertile females being entirely brought about by the difference in food. This, however, is not the case with the males, and it is a disputed point whether the queen can control the sex of any particular egg, or whether she can select a male egg as she proceeds with the laying. Certain it is, at any rate, that when she reaches a drone or male cell, which is larger, she deposits an egg which will become a male. It has usually been asserted that unfertilized eggs become males, while those which are fertilized turn out females. This may be the case, and certainly would tend to bear out the general truth that absence of nutrition tends to give the male element greater preponderance in the progeny, though the immediate physical conditions on which the sex of the offspring depends are imperfectly known. A superabundance of males is, as a rule, associated with failing provisions and loss of bodily energy, and this is borne out by the fact that when the queen is old she is apt to lay too many drone eggs. This, however, is a failing which the community cannot put up with, and if the queen be unable to produce profitable offspring she is put to death. Still both bees and queens well know that the one supreme calamity which can befall the bee community is to be left without a queen, not because they need her rule, but because on her alone rests the future of the colony. And it has been asserted that if two queens only remain, and are con-

testing for the mastery, and each should simultaneously have the chance to deliver a sting which might prove fatal to both, each releases the other, dreading to leave the hive queenless.

Swarming

Inseparable from these phenomena is that of swarming or the budding off of new colonies from the mother hive. Owing to the instinct of the workers, who can arrest or accelerate development by regulating the food supply, a new queen is always ready when a swarm of bees is prepared to leave the overcrowded hive. This queen is, however, not permitted to leave her cell till the actual moment of flight; and all along has to be protected from the reigning queen, by whom, if opportunity were afforded she would be killed. Indeed, when the swarming season is over, the actual sovereign is permitted to make short work of all her rivals. The function of the nurses, as their name implies, is to rear the young, and, if necessary, preserve the queens. After the males, or drones, have fulfilled their duties, they are massacred in thousands by the workers; even the young grubs and pupæ being dragged from their cells and killed. In many wasp societies, these matters are, however, more leniently arranged, since the males usually assist in the general duties of the colony. Still even these exhibit an unaccountable habit, all the grubs and pupæ being dragged out and slain as winter approaches. Whether the wasps themselves begin to experience the pinch of hunger, and wish to close mouths which must otherwise starve, or what may be the motive for such action, is beyond our ability to guess. Since every wasp, save here and there a large female, or queen, perishes at the approach of winter, the massacre cannot be justified on the score of prudential social policy.

Solitary Wasps and Mud Wasps — Families *MASARIDÆ* and *EUMENIDÆ*

The true wasps may be conveniently divided into solitary and social wasps, al-

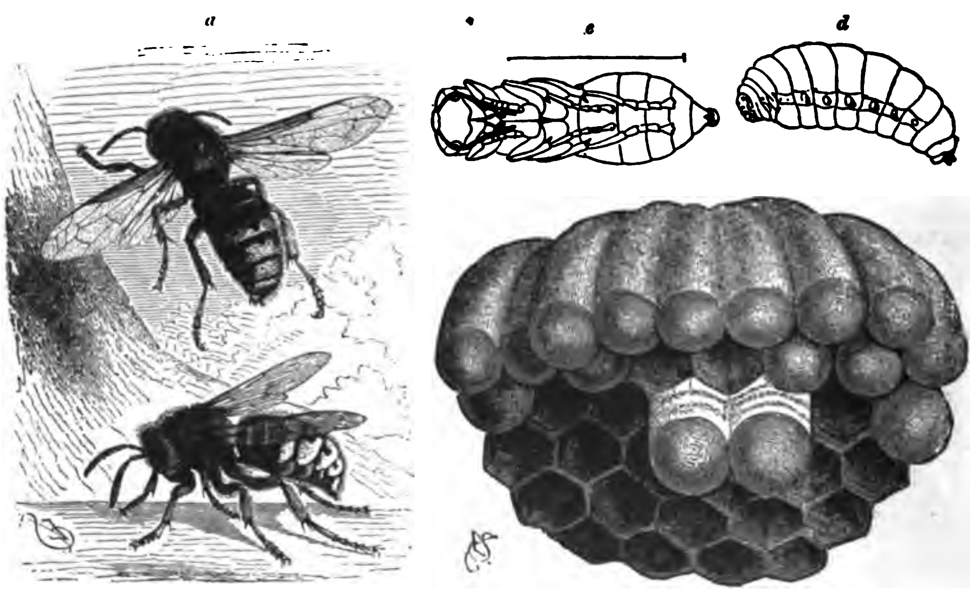
MUD WASPS.
1. *Odynerus parietum*, female, with nest; 2. *Chrysis ignita;* 3. *Polistes gallica*, female and nes

though there is a more or less complete transition between the two. Of the typical solitary wasps (*Masaridæ*), which are mostly tropical forms, and constitute a link

between the parasitic wasps described above and the *Vespidæ*, but little is known. Some kinds are, however, parasitic, and possibly many may be so. On the other hand, the *Eumenidæ* are solitary wasps, which make their nests chiefly in mud walls or sandstone cliffs; some constructing a series of mud cells in hollow stems of plants, and supplying their grubs with caterpillars for food. A well-known European example is the figured *Odynerus parietum*, a variable insect, making its appearance in May and June. The nests are made in holes of old mud walls, or the banks of clay pits, and are filled with grubs of beetles belonging to the family *Chrysomelidæ*, or with the caterpillars of small moths.

SOCIAL WASPS — Family *VESPIDÆ*

The members of this group form a link between the foregoing and the true bees, since each species includes a fertile female or queen, unfertile females or workers, and males or drones. The nests are formed of a kind of paper manufactured from the dry parings of old posts and trees. Since we have already dealt briefly with the general habits of the *Vespidæ*, further reference to them, save as



LIFE HISTORY OF THE HORNET.
a. b. Adult; *c* Portion of brood cells; *d.* Larva; *e.* Pupa. (*d* and *e* somewhat enlarged.)

occasion for their mention arises in the course of subsequent description of species, will be unnecessary. The members of the family may themselves be distinguished at once from all other Hymenoptera by the peculiar arrangement of the wings when folded at rest. The fore-wings partly inclose the hind-wings, both pairs lying along the sides of the abdomen, not concealing it from above. The food of wasps consists of the saccharine matter derived from various vegetable products

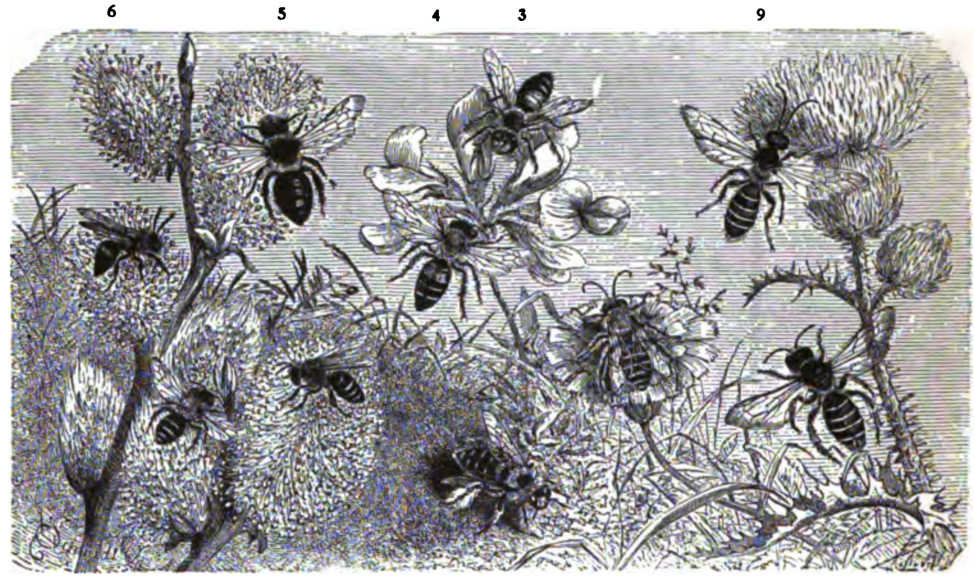
and also from animal matter. As regards the distribution of species — apart from the usual increase in size and beauty of coloring — it may be remarked that the closer the equatorial regions are approached, the more numerous do members of this group become. Of the better-known forms the common hornet (*Vespa crabro*) is readily distinguished from other species of wasps by its large size and the prevailing red tint on the anterior portions of the body. It is universally distributed throughout Europe, and occurs as far north as Lapland. The solitary female, after her hibernation, commences to build the first foundation of her nest in May on some convenient beam in a loft or outhouse, or frequently in the holes made in the eaves of thatched cottages by sparrows. The food of the grubs consists of the bodies of insects, bees, etc., which the workers chew up for their benefit. On the approach of autumn the remaining larvæ, which have not yet been hatched out, are torn from their cells and left to perish. Under the title of common wasps no less than five species may be included, although *V. vulgaris* is the common wasp *par excellence*. *V. germanica* may be recognized by the three black spots on a yellow clypeus. *V. vulgaris* presents a longitudinal black line dilated at the extremity. *V. rufa* is rare in Northern Europe. *V. media* has the yellow markings of the abdomen darker than in the other species. The wood wasp, *V. silvestris*, hangs its nest on the bough of a tree or shrub. Such brief notices are, of course, wholly inadequate for a student of the group; and reference must be made to writings devoted to the special points of difference between these closely-allied species. Among other forms space only admits mention of the South-African wasp (*Belonogaster*), of which the comb is shown in the annexed figure. Common in houses at the Cape, this insect is much dreaded on account of the severity of its sting.

SOUTH-AFRICAN WASP AND ITS NEST.
(Natural size.)

SOLITARY BEES — Family *ANDRENIDÆ*

These insects may be recognized by the fact that the pollen-collecting organs are situated on the femora and coxæ of the hind-legs, and the neighboring sides of the thorax. The genera *Andrena* and *Hylæus* comprise the greater part of all the wild bees of Central and Northern Europe. The perfect insects appear in the early spring, making their nests in sandy soil. In the first genus figures of three species (*A. schencki*, *A. cineraria*, and *A. fulvicrus*) are given in the following illustration. *H. grandis*, figured on the same illustration, flies in July and August, and forms a large number of holes — a kind of colony — in some sunny slope. The species of both *Andrena* and the allied *Halictus* are parasitic, and dis-

play a very curious habit. When retiring to rest they fasten upon a twig or the edge of a leaf with their mandibles, fold their wings, draw up their legs, lay the antennæ neatly along their backs, and, having induced a temporary lockjaw, hang securely until the morning, when they loose their hold and hurry off once again to play the parasite on their relatives. Another species figured in the illustration is the hairy-legged bee (*Dasypoda hirtipes*), which appears on the wing in July, and constructs a nest of about six cells in sandy ground. The burrow runs obliquely at first, afterward descending perpendicularly. Another well-known type of the family is exemplified by the mason bees, of which one species (*Chalicodoma muraria*) is represented in the illustration on p. 3007. These insects make their appearance in Europe during May, when the female forthwith sets about construct-



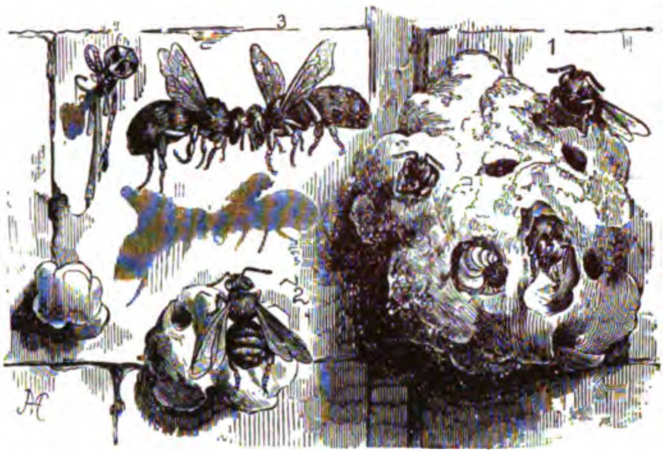
GROUP OF SOLITARY BEES.

1, 2. Hairy-legged bee (*Dasypoda hirtipes*); 3, 4. Shenck's earth bee (*Andrena schencki*); 5, 6. Gray-haired earth bee (*Andrena cineraria*); 7, 8. Brown earth bee (*A. fulvicrus*); 9, 10. Large burrowing bee (*Hylæus grandis*). A male and female of each is figured. (All of natural size.)

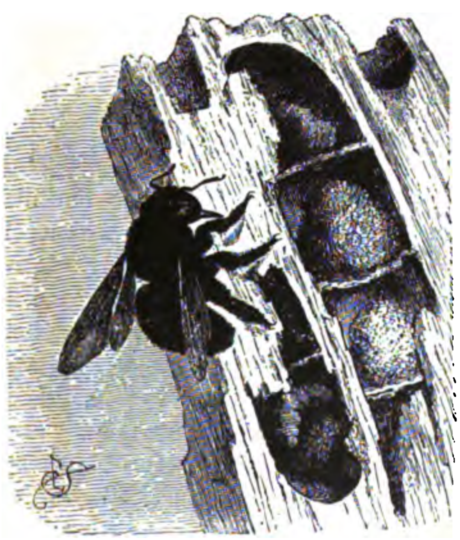
ing her nest. This includes not more than ten simple cells, and is attached to old walls or houses; the cells being formed of grains of sand glued together with the saliva of the builder. In 1886 some bees of an allied genus (*Osmia*) constructed their nests in the locks of a door at Deptford. The cells had completely choked the works of the locks, and in one case a portion of the nest was forced out by the insertion of the key without driving away the bees. As the locks were in pretty constant use, it would appear that all the nests must have been built within a few days.

The leaf-cutter bees, of which an example (*Megachile centuncularis*) is figured in the illustration on p. 2999, take their name from lining their nests with cells made from fragments of leaves nipped out by the strong jaws of the insects. These cells may be placed either in the holes of trees, in clefts and crannies of old

walls, or in specially constructed burrows in the ground. Among the leaves most generally employed are those of the poplar, hornbeam, privet, poppy, and rose. The mode in which these insects work, and the structure of their cells and burrows are exhibited in the illustration. Yet another type of building is exemplified by the carpenter bees (*Xyloeopa*), which are among the finest members of the entire family. Their ceils are built in rows in the solid wood of trees, and the method of procedure will be observed in the illustration exhibiting the violet carpenter bee (*X. violacea*). This species, which is rare in Northern Europe, forms a series of cells in each of which lies a larva, and since the lower ones are obviously the oldest, it is somewhat difficult to understand how the newly emereged perfect bee escapes into the upper air from the lower cell. At present it is not altogether clear what course it takes; whether it gnaws its way through the chambers where brothers and sisters are peacefully awaiting future developments—at the imminent risk of arresting all chances of such by thus breaking into their bedrooms, to the detriment of nervous systems not yet hardened to bear the strain—or whether it gnaws its way straight out at the side, seems a matter of doubt. Some authorities state that the female has already foreseen and guarded against such undesirable contingencies, by preparing a door of escape at the bottom of the lower cell. And they record as a remarkable fact that the bees, each in turn, gnaw through the floor of its cell, and of course find their elder brother or sister already flown from the cell next below. They never go in the opposite direction through the roof. Our next examples of this family are the flower bees (*Anthophora*), of which three species are shown in the following illustration. In general appearance these insects closely approximate to humblebees. They build their nests in bur-

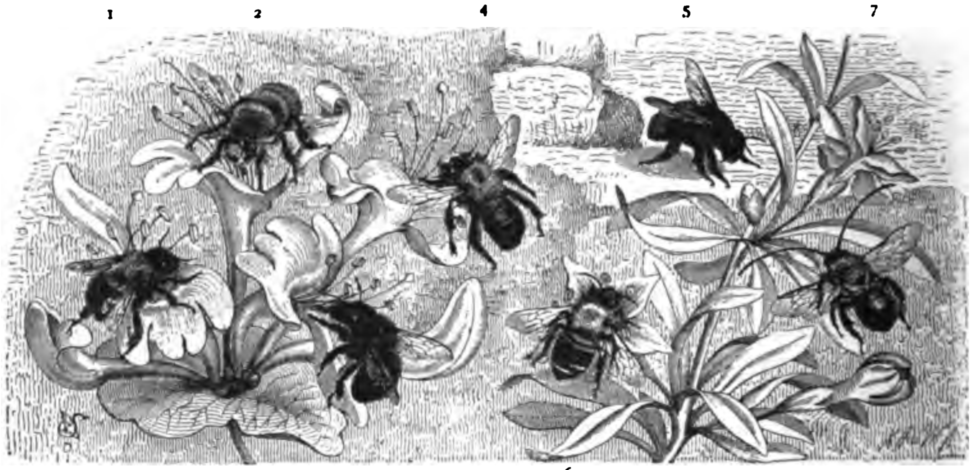


MASON BEE.
1. Nest with bees emerging and larva in an open cell; 2. Male; 3. Females fighting. (Natural size.)



VIOLET-WINGED CARPENTER BEE, WITH CELLS CUT OUT IN A TREE STEM.

rows in the ground, in holes of trees, or clefts and cracks in walls; the cells being separated by partitions, and made of the ruins of the burrow or cleft. Generally the whole nest has the form of a twisted tube. Like their allies, these bees are solitary, and, like humblebees, are much infested by parasites. Finally, we have



1, 2. HAIRY-LEGGED FLOWER BEE (*Anthophora hirsuta*), female and male; 3, 4. TUFTED FLOWER BEE (*A. retusa*), female and male; 5. WALL-NESTING FLOWER BEE (*A. parietina*), female; 6, 7. LONG-HORNED BEE (*Eucera longicornis*), female and male. (All of natural size.)

the long-horned bees, of which one species (*Eucera longicornis*) is shown in the illustration. These bees construct smooth tunnels in the earth, divided as usual into sections, each of which contains one egg, together with a supply of pollen and honey for the future larva.

TRUE BEES—Family *APIDÆ*

In this group are included not only the various kinds of honeybees, but likewise their more clumsy cousins the humblebees. Such a well-known insect as the common honeybee (*Apis melifica*), of which the habits have been already referred to, requires no special notice; but it is important to observe that the honeybees of the equatorial zone differ somewhat from those inhabiting more temperate regions, in consequence of which they are assigned to distinct genera, such as *Melipoma*, *Trigona*, and *Tetrasoma*. All these are rather small and stingless bees, making up for the absence of a special weapon of offense by a free use of their jaws. Their brood cells and combs resemble those of the common wasp, each forming but a single layer; and clay and resinous substances being chiefly used for closing the entrance of the cavities in which the nests are placed. The characteristic transitional features in the shape of the cells, intermediate between the simple cylindrical and the perfect hexagonal forms, have already been noticed in the short introductory remarks. *Melipoma* and its allies form the connecting link between the solitary and the hive bees. As in the wasps, each family in the humblebees owes its origin to

a single female which has hibernated—usually in some hole in the ground which it excavates for the purpose. The hive bees, on the contrary, swarm, that is, they send off a full-grown population under a queen ready to enter upon the organized life of an industrial community at once. The different forms of humblebees are much the same as those of the hive bees, namely, large females; workers or undeveloped females; small females which are similar to the large (or queens) in structure; and males. One very strange habit has been recorded and confirmed by subsequent observations. A small female is set apart for the duty of awakening the nest every

1 2

1. COMMON HUMBLEBEE WITH NEST; 2. STONE HUMBLEBEE.
(Natural size.)

morning with her piercing note, and has been called the "trumpeter." It seems that only those nests which are large and have plenty of spare hands can afford this luxury.

Humblebees, both as regards appearance and habits, are too well known to need description. Of the two species figured in the annexed illustration, the common humblebee (*Bombus terrestris*) forms small rounded nests of carded moss. On the other hand, the stone humblebee (*B. lapidarius*) makes its habitation in cavities among stones, where it forms an oval nest, of which only the sides are covered with moss and grass.

CHAPTER II

JOINTED ANIMALS—*continued*

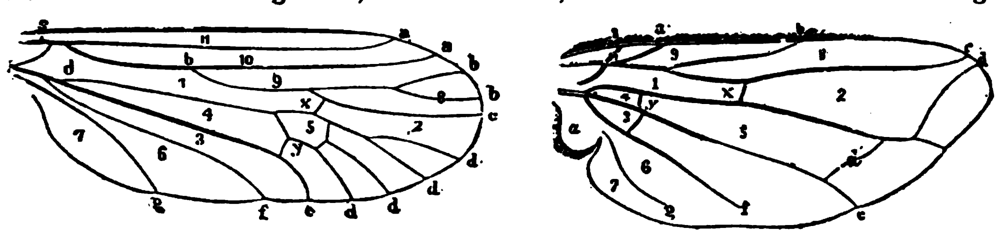
INSECTS — *continued*

THE FLIES AND FLEAS — Order DIPTERA

AS IMPLIED by their scientific name, the typical members of the order now claiming attention are distinguished from all other insects by the possession of but a single pair of wings. In this case one pair of these organs has disappeared, and examination will reveal the fact that it is the front pair that is retained in full functional importance, while the hinder pair has become reduced to a couple of short slender club-like organs, known as *halteres* or balancers. From their small size it might be supposed that these balancers were organs of but little physiological importance, but the experiment of removing them will show that this is not the case; for an insect thus mutilated is thereby entirely deprived of the power of maintaining its equilibrium and of directing its course in the air. Hence the name balancers that has been assigned to these rudimentary wings. The mouth parts, instead of being of the primitive mandibulate type, are formed for purposes of piercing or sucking. In the former kind of structure, as represented for instance in *Pangonia longirostris*, one of the horseflies (*Tabanidæ*), these organs are composed of seven pieces, which have been interpreted by Mr. Waterhouse as follows: The uppermost is a long pointed instrument, the labrum. Immediately below this, and more or less concealed by it, is an almost equally long and slender piece, which is probably the hypopharynx. The mandibles are modified into a pair of sharp lancets, and below them are two extremely slender instruments, which from the presence of palpi, are recognizable as parts of the maxilla. All these pieces lie concealed in the basal half of the proboscis, which, for part of its length, is gutter shaped, but afterward assumes the form of a tube, and is believed to be comparable to the labium In the gnats the mouth is formed upon the same plan, but the lancets are all more slender. In piercing the skin the lancets only are used, the labium or proboscis serving merely as a guide. In the flies that use the mouth for sucking — as for instance in the blowflies and drone flies — the jaws are still more modified, so that the identity of the separate pieces is difficult to establish. The most prominent part is the proboscis, the expanding terminal lobes of which are the *paraglossæ* of the labium. The maxillæ are represented by two scales or short stylets closely adherent to the sides of the proboscis, and of two club-like palpi; but the mandibles seem to have disappeared.

The only characteristic that need be specially noticed in the wings is that they are usually naked,— being but rarely furnished with short hairs,— and that the veins are almost all longitudinal, that is, they run from the base or point of attachment

of the wing to its free margin. These veins are represented in the accompanying figures by the letters *a, b, c, d, e, f, g*. The transverse veins *x, y*, on the contrary, are always few in number. The shape and size of the spaces (indicated by the numbers 1, 2, 3, etc.) circumscribed by these veins form valuable systematic characteristics for distinguishing the species and genera of this order. The balancers may be entirely exposed, as in the common daddy longlegs, but are sometimes concealed by a scale-like membrane as in the bluebottle fly. In connection with the wings may be noticed the buzzing of flies. This appears to be the result of two distinct sounds, one produced by the rapid vibration of the wings, and the other by the vibration of the thorax. The latter movement is the more rapid of the two, and gives rise to the shrill note heard the moment a blowfly is seized; while the former is the ordinary buzzing produced when the insect is in flight. According to recent calculations, the thoracic vibrations in the case of one of the humblebee flies (*Volucella*) amounted to thirteen hundred per second, while those of the wings were just one-half this number, namely six hundred and fifty per second. The legs possess the normal five segments; the tarsi or feet, which are also divided into five seg-



WING OF DADDY LONGLEGS AND OF BLOWFLY.

ments, being armed with two claws, and in addition, often supplied with adhesive pads, by means of which the insects are enabled to ascend perfectly smooth surfaces. These pads are composed of a multitude of funnel-shaped hairs, each supposed to act as a minute sucker. Some authors assert, however, that they secrete a sticky fluid, and that the insect maintains its hold by this means. The antennæ vary considerably in structure. In their least modified form, as presented by the gnats and their allies, they are simple and thread-like organs, consisting of a series of subequal segments, often modified by the presence of long symmetrically-arranged bristles, which impart to them a feather-like aspect. In most of the members of the order the antennæ are, however, curiously constructed. The three basal segments are stout, the third being especially large and produced into a great lobe-like plate, sometimes projecting as far as the extremity of the terminal part of the organ, which frequently has the form of a plume-like whip, the *flagellum*, although sometimes reduced to a bristle. Not unfrequently the antennæ differ greatly in structure according to sex. In the males of gnats, for example, they are large and feathery, while in the females they are only furnished with short hairs. The males and females of most of the common flies, on the contrary, may be recognized by the development of the compound eyes. In the former sex these organs are almost in contact on the summit of the head, while in the latter there is a widish space between them. Rarely the sexual characteristics are much more pronounced, as for

instance in the stag-horned flies, in which the head of the male is furnished with large branching processes, and the stalk-eyed flies, in which the eyes in this sex are supported upon long, horizontal, immovable stalks.

Like the other higher orders of insects, flies, in the course of their development, go through a complete metamorphosis; the larvæ — of which perhaps the commonest are maggots and cheese hoppers — being worm-like, and passing into a partially or wholly quiescent pupal stage before attaining maturity. These larvæ differ much in structure in some of the families; those of the gnats having a well-developed head, with the antennæ, mandibles, maxillæ, and labium always recognizable; whereas in the maggots of the blowfly the head is narrow and pointed, without antennæ, and with the mouth parts reduced to a pair of retractile hooks, the opposite extremity of the body being broad and square cut. It must not be supposed, however, that the larvæ of all the members of this order are of one or other of these two types. On the contrary, the structure varies according to habitat, and almost every gradation is found linking the two together. Some species live in fresh-water ponds and streams, others in the earth among roots of grass, others again in rotting animal or vegetable matter, and others, like the maggots of the warble fly, in the stomachs of the hosts they infest. Thus the nature of their food and surroundings is extremely varied, and that the larvæ are likewise so, may be seen by a glance at the figures in the following pages.

Upon reaching its full size the larva passes into the pupal stage. The pupa, however, exists under two conditions. In one case, as in the gnats, it emerges from the skin of the larva and leads an independent life of longer or shorter duration, until the attainment of maturity; in the others, as in the fly called *Stratiomys*, it remains within the larval skin, which becomes thickened and constitutes a protective covering for it. Again, the rupture of the larval skin for setting free the pupa is effected in one of two ways. In the first case the opening is T-shaped, consisting of a longitudinal split on the back behind the head, or rarely of a transverse split between the seventh and eighth segments of the body; in the second case a circular split occurs behind the head, which is pushed off like a kind of cap. These two methods of splitting of the larval skin have been used as characteristics for dividing the Diptera into two suborders, those in which the pupa escapes in the former way being termed straight-seamed flies, or Orthorrhapha, and those in which the pupa escapes in the latter way circular-seamed flys or Cyclorrhapha. For the rupture of the larval skin, the pupæ of the Cyclorrhapha are furnished with a bladder-shaped excrescence on the front of the head. In the vast majority of flies the young make their first appearance in the form of eggs. In some few cases, however, as in the genera *Sarcophaga* and *Mesembrina*, belonging to the family *Muscidæ*, the young are born as active maggots; while in the forest flies and their allies only one matures at a time, and this is retained by the mother and nourished at her expense until it has passed into the pupal stage. The most anomalous method of reproduction occurs in one of the gall midges, where the larvæ themselves produce other grubs by a process of internal budding.

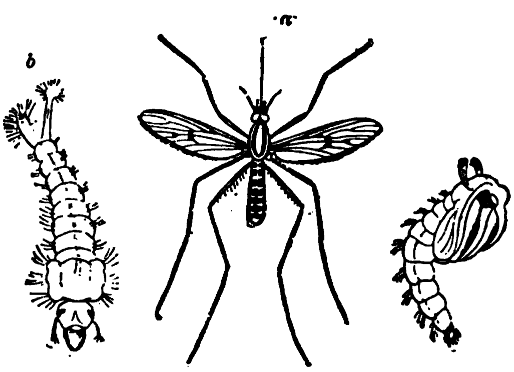
That flies were abundant in early Tertiary times, when they were not very different from those that now exist, is shown by the abundance of their remains

preserved in the amber beds of the Baltic. Strata of the same age at Florissant, Colorado, have also yielded fossil flies. A few have been obtained from Secondary rocks.

THE STRAIGHT-SEAMED FLIES — SUBORDER **Orthorrhapha**

The first section of this suborder contains the gnats and mosquitoes (*Culicidæ*), daddy longlegs (*Tipulidæ*), true midges (*Chironomidæ*), and fungus midges (*Mycetophilidæ*). These families are sometimes spoken of collectively as the Nematocera, or flies with thread-like antennæ, on account of the length and thinness of those organs, which usually consist of as many as ten or more segments. The maxillary palpi also are elongate, and the body and limbs present, as a rule, the type with which we are familiar in the gnats and daddy longlegs.

Mosquitoes and Gnats The mosquitoes and gnats (*Culicidæ*), although often regarded as distinct, are in reality identical. They abound in all lands, and may be met with in cold barren countries like Iceland and Lapland as well as in the dense forests of tropical climes, everywhere being the plague of travelers on account of their insatiable thirst for blood and the intense irritation caused by their bite. It is, however, only the females that bite and suck blood, and in this connection it may be pointed out that no members of the Diptera sting in the sense in which the word is used with regard to ants and wasps; that is to say, the wound, although giving rise to a sharp stinging sensation, is inflicted by jaws, and not, as in the case of the ants, by an organ especially designed for the purpose placed at the hinder extremity of the abdomen. The annexed figure representing the banded gnat (*Culex annulatus*), a species sometimes found in houses, and noticeable for being the largest British form, is selected to illustrate the mode of life characteristic of the members of this family. The long slender eggs, amounting to some three hundred or more, laid by the mother in batches on the surface of a pond or ditch, give rise to worm-like larvæ furnished with a distinct head, a large somewhat squared thorax, and a tapering jointed abdomen. Along each side of the body there is a row of bristle tufts, one for each segment, and the last segment is in addition produced into a couple of tubular tails, at the extremity of which open the tracheæ or breathing tubes. Thus equipped, the young gnat hangs suspended in the water, its heavy head directed downward, and the tip of its forked tail just projecting above the surface, so that the apertures of its breathing apparatus are in communication with the air. Occasionally when the surface of the water is disturbed, or from any other reason causing alarm, the larva wriggles to the bottom of the pond, soon,



BANDED GNAT.
a. Female; *b*. Larva; *c*. Pupa. (All enlarged.

however, to return to its accustomed place at the surface. During growth, the larva undergoes a series of three molts before reaching its full size, the newly-clothed insect escaping from the old skin through a longitudinal slit behind the head. At the fourth molt emerges the pupa, which is a very different looking creature from the larva, showing the cases for the antennæ, wings, and legs of the adult, while from the sides of its thorax project a pair of tubes, analagous to those of the larval tail, and like these carrying the apertures of the tracheæ. By means of its jointed abdomen the pupa jerks itself about in the water in company with others of its kind. At the appointed time a longitudinal slit occurs on the back behind the head, and, extricating itself from its pupal case, the adult gnat appears on the surface of the water, where under favorable conditions its skin hardens and its wings unfold, while it floats upon the water using its discarded clothing as a raft. If this time of danger be successfully overcome, the insect takes wing and joins its companions in their mazy dance; but, before acquiring strength to do so, it is at the mercy of every wave or gust of wind, and if once swept back into the water, its chances of survival are small. The before-mentioned banded gnat may be distinguished from other British species by its large size, its spotted wings, and striped legs and abdomen. The common gnat (*C. pipiens*), which is often abundant in houses in the autumn, is much smaller and without the ornaments characteristic of its larger ally.

Travelers in the tropics are so familiar with mosquitoes that nothing we can say can add to their knowledge of the subject. But to give those who have been fortunate enough to avoid a practical acquaintance with them some idea of the torments caused by these little pests, we quote the following passages from the works of two well-known naturalists. Speaking of his sojourn at a place on the Amazons, Bates says "at night it was quite impossible to sleep for mosquitoes; they fell upon us by myriads, and without much piping came straight at our faces as thick as rain drops in a shower. The men crowded into the cabins and then tried to expel the pests by the smoke from burnt rags, but it was of little avail, although we were half suffocated by the operation." Again, Emerson Tennent writes that "of all the insect pests that beset an unseasoned European, the most provoking by far are the truculent mosquitoes. Even in the midst of endurance of their onslaughts one cannot but be amused by the ingenuity of their movements; as if aware of the risk incident to an open assault a favorite mode of attack is, when concealed by a table, to assault the ankles through the meshes of the stocking, or the knees which are ineffectually protected by a fold of Russian duck. When you are reading a mosquito will rarely settle upon that portion of your hand which is within range of your eyes, but cunningly stealing by the under side of the book, fastens on the wrist or little finger and noiselessly inserts his proboscis there. I have tested the classical expedient recorded by Herodotus, who states that the fishermen inhabiting the fens of Egypt cover their beds with their nets, knowing that the mosquitoes, although they bite through linen robes, will not venture through a net. But notwithstanding the opinion of Spence, that nets with meshes an inch square will effectually exclude them, I have been satisfied by painful experience that, if the theory is not altogether fallacious, at least the modern mosquitoes of

Ceylon are uninfluenced by the same considerations which restrained those of the Nile under the successors of Cambyses." An interesting question arises in connection with mosquitoes as to the nature of the food of the vast hordes of them that frequent the tropics. It is true that the females alone bite; but the proboscis is a highly perfected organ for piercing and sucking, and it might be supposed that it is extensively used for the purpose. Yet it has been pointed out that the vast majority of mosquitoes can never taste mammalian blood. In various places, such as parts of India for example, mosquitoes are found in swarms in spots never visited by human beings, and in which there are no large mammals. It has been suggested that, failing to obtain blood, mosquitoes support themselves on the juices of plants, but no observations in support of this have been recorded.

Daddy Longlegs

The daddy longlegs (*Tipulidæ*) contain the finest species of this division of the order; the largest European form being the giant daddy longlegs (*Tipula gigantea*), which has its wings clouded with brown, and measures about one and one-fourth inches in length. Much larger kinds are, however, met with in Burma and China. The short and fleshy proboscis is not adapted for piercing, but merely for absorbing fluids; and the antennæ are not feathery as is so often the case in the gnats and midges, although in the species of the genus *Ctenophora* — which are of stouter build, and often brightly colored black and yellow, thereby resembling some of the sawflies — the antennæ are pectinated in the male. In this family the eggs are laid and the larvæ undergo their growth and change of form either in water or earth. The females of two of the commonest British species (*T. oleracea* and *T. paludosa*) may be seen in summer and autumn flying about meadows and depositing their eggs here and there in the soil. When hatched, the larvæ start feeding upon the roots of grass and corn, thereby doing considerable damage to farmers and gardeners, to whom they are known by the name "leather jackets."

Midges

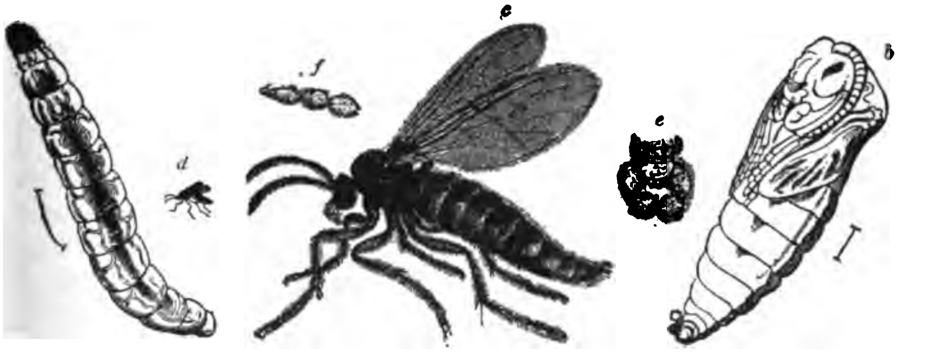
The true midges belonging to the family *Chironomidæ* are nearly allied to the gnats, with which they are often confounded; but the mouth parts are rarely adapted for piercing, the proboscis being short and soft. In the genus *Ceratopogon* the jaws of the females are, however, lancet shaped, and capable of drawing blood. The little black midge that in the summer settles upon the hands and face and inflicts a sharp prick belongs to this genus. But the best-known member of the family is the plumed midge (*Chironomus plumosus*), which on summer evenings may be seen dancing in swarms along roads and lanes. Its name has been given to this species on account of the beautiful feathery-like antennæ of the male. In connection with this species a case of luminosity has recently been recorded. An observer in Russian Asia found on the shores of Lake Issyk Kul a number of examples of this midge, and of an allied form belonging to the genus *Corethra* emitting a phosphorescent light. Failing to discover any luminous organ he came to the conclusion that the light was due to the presence in the insect of multitudes of parasitic bacteria, an opinion strengthened by the observation that the shining individuals were sluggish and never seen on the wing.

The fungus midges (*Mycetophilidæ*) take their name from the fact that the larvæ of most species feed upon fungi of various kinds. The perfect insects, which fre-

(3016) A COLUMN OF THE ARMY WORM.

Fungus Midges

quent damp situations, are all of small size, and mostly pale in color. To this family belongs the so-called yellow fever fly, a species of the genus *Sciara*, which in North America is said to appear when yellow fever is prevalent. But perhaps the most notorious species is the so-called army worm fly (*Sciara militaris*), which has long attracted attention on account of the peculiar habits of the larvæ. This fly is completely black, with the exception of its legs, which are brownish. The female, which is represented of the natural size at *d*, in the accompanying illustration, and enlarged at *c*, is larger than the male, and has the abdomen terminating in a pointed stylet. In the male, on the contrary, there is at the apex of the abdomen a pair of thick two-jointed claspers, and between these a couple of small adjacent processes, as shown at *e*. The extremely small eggs are laid by the mother, to the number of about one hundred, upon soil among fallen leaves on which the larvæ feed. On attaining maturity, these larvæ measure nearly a quarter of an inch long, and have the form represented at *a*. The black head is distinct, and furnished with eyes, and the semitransparent body consists of thirteen segments, some of which are furnished with lateral black stigmata. In many countries of Europe where this insect is met with, vast hosts of these maggots, forming a compact mass, sometimes several feet long and an inch or two



ARMY WORM FLY (*Sciara militaris*).

a. Larva; *b*. Pupa; *c*. Female midge; *d*. The same (natural size); *e*. End of abdomen of male; *f*. A portion of the antennæ. (Magnified, except *d*.)

broad, have been seen at times creeping along at a slow pace through the woods like a grayish serpent. The maggots crawl along, not only side by side, but also one over the other, all adhering together by their sticky surfaces, and continually changing their position in the column. At the close of their march, when fatigue or want of nourishment causes them to rest for a time, the larvæ composing a single train collect into a ball, which gradually diminishes in size, and finally disappears by the burrowing into the mold of those that are lowest in the mass. For a long while the reason for this peculiar habit remained wrapt in obscurity, and perhaps even yet we do not understand its full significance. In has been suggested, however, that when the supply of food for the multitude runs short, the whole army is moved by a sudden impulse to start in search of fresh supplies. It is almost superfluous to add that the peasantry of the countries where this strange phenomenon is observable, failing to understand its true significance, have from time

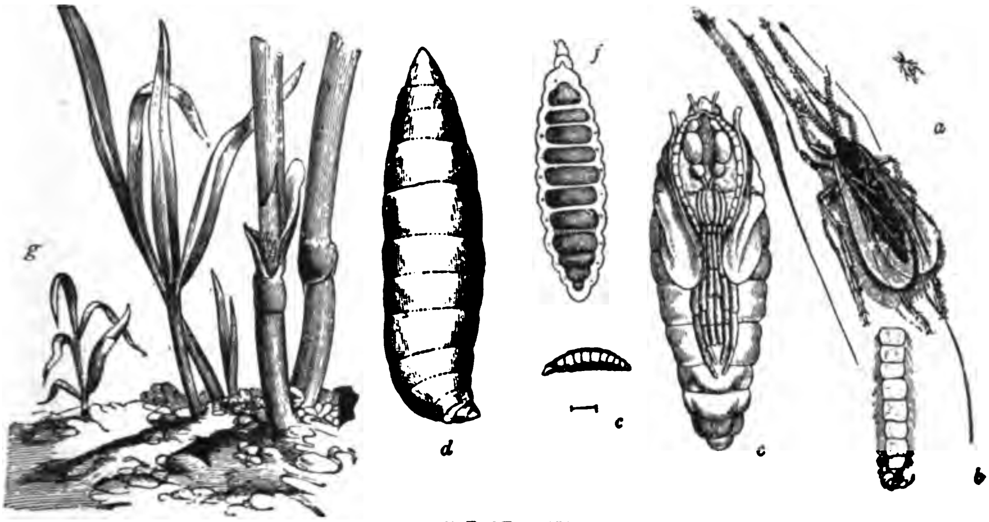
immemorial regarded it as something supernatural, and as foretelling various events in the future, some looking upon it as a sign of the imminence of war, others of the destruction of their crops, etc. The pupa of the army worm is shown at *b* in the figure on p. 3017. This stage lasts from eight to twelve days; but the perfect insect is short lived, the female surviving apparently only long enough to pair with the male and lay her eggs.

When speaking of one of the true midges reference was made to a pathological case of phosphorescence, but in the present family there are two instances known of the normal occurrence of this phenomenon — not, however, in the adult insect, but in the larval or pupal stages. The first instance is furnished by *Ceroplatus sesioides*, a midge, which although not yet known to occur in England, has been met with in several of the countries of Europe. Here the luminosity is said to resemble that of the glowworm, but proceeds from the entire animal, and from members of both sexes. The larvæ, which are found in small colonies on the under side of a fungus, exhibit, when crawling in the dark, a moving streak of light, less bright than that emitted by the pupæ. The insect also shines when lying in the cocoon, so long as its abdominal rings are still transparent and have not attained their complete coloring. The cocoons themselves are not luminous, but allow the light to be transmitted as through a paper lantern; and since as a rule several of them are situated together a more extensive glow is displayed, whereby both the cocoons themselves and the surrounding objects are illuminated. When the insect is about to emerge from the cocoon, the luminosity gradually diminishes, and ultimately ceases altogether. The second instance is presented by a New Zealand midge called *Boletophila luminosa*, the larva of which is known as the "glowworm." Here the female is luminous in all three stages of its existence, but in the male the luminosity disappears two or three days before the emergence of the perfect insect. The luminous organ, which is situated in the posterior part of the body of the larva, consists of a gelatinous, semitransparent structure, capable of extension, contraction, and other changes of form, and, like its luminosity, is completely under the animal's control. As to the part played by this organ in the midge's economy, authors are at variance; one believing that the light serves to attract small creatures, so that they become entangled in a web of mucus, which the larva suspends in some niche in the soil.

Gall Midges

The gall midges (*Cecidomyidæ*) are minute, fragile insects, in which the wings are furnished with few veins, are often hairy, and always fringed on the edges. From an agricultural point of view, these insects are the most important of all the gnat-like flies, since much damage is at times done to crops by their larvæ. The most notorious is the Hessian fly (*Cecidomyia dessauctor*), represented in its various stages in the following illustration. This insect was believed to have been introduced into North America by the Hessian troops at the time of the War of Independence, whence the inhabitants of the United States gave it the name by which it is now commonly known. The adult female, which measures rather less than a tenth of an inch, is mostly of a velvety black color, varied with blood red, especially on the abdomen; while the rather larger male is browner, with the red clearer. These flies may be observed on the wing during the second

half of April. They live, however, only for a few days, and perish soon after laying their eggs, which amount to about eighty or a hundred. These are placed separately or in pairs upon the leaves of the wheat plant, and in a short time hatch, when the larvæ crawl down the leaf, reach the stalk, and burrow in it to take up their abode and feed upon its tissues. This does not immediately, nor in a direct manner, cause the death of the plant, but, weakening its stem, renders it liable to be beaten down by wind or rain, and causes it to bear inferior corn if it reached maturity. Toward the end of July the larvæ are full grown, and pass into the pupal stage; while at the end of August or the beginning of September the adults again appear and lay their eggs on winter wheat, the larvæ that are hatched from these passing the winter in the pupal state and completing their development in the spring. Nearly allied is the wheat midge (*C. tritici*), which, as its name in-



DEVELOPMENT OF HESSIAN FLY.

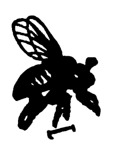
a. Female enlarged and of natural size; *b.* Abdomen of male; *c.* Pupa; *d.* Skin of larva forming pupa case; *e.* Larva seen in profile (the line representing its natural size); *f.* Larva from above (enlarged); *g.* Wheat stalks infested with larvæ.

dicates, also attacks the wheat plant, to which it at times does great damage. The female lays her eggs—often in numbers—not on the leaves or stems, but in the heart of the blossom, and their presence either entirely prevents the formation of any seed, or renders that produced of a poor kind.

There are many other species of gall midges which attack different kinds of plants, such as the willow, hawthorn, etc., but lack of space forbids further reference to them. One only (*Miastor metroloas*) demands attention on account of the remarkable powers of reproduction of its larvæ. In the majority of cases insects are only able to reproduce their kind after attaining the adult state, the larvæ being merely the young modified for a free and active existence; but the larvæ of this midge, which are found under the bark of trees, possess the remarkable power of producing within their bodies living young. These grow to a certain size at the expense of their parent, whose vitals they devour, then rupture the empty skin and start life on their own account. The second larvæ repeat the same

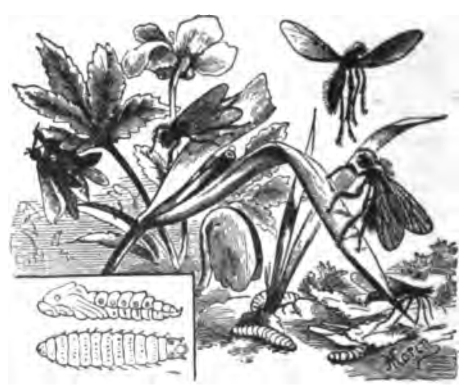
process of reproduction, and so the phenomenon continues through the cold months of the year. At the beginning of the summer the process comes to an end, and the larvæ fulfil their destiny and give rise to mature insects in the ordinary manner.

Sand Flies, etc. The two families now to be mentioned have been termed the anomalous, or fly-like Nematocera, since although their antennæ are many jointed, they are shorter than in the foregoing families, and their limbs and bodies instead of presenting the aspect of those of the gnats and midges, are shorter, thicker, and closely approach in this respect those of ordinary flies. To the family *Simuliidæ* belong the minute "sand flies" of the tropics, which surpass even the mosquitoes in their venomous bite, and on account of their minute size are far more difficult to cope with. In these insects the mouth parts are adapted for piercing; and the early stages of life are passed in water. The best-known European example is the Columbatsch fly (*Simulia columbatzensis*), taking its name from a village in Servia, where it is a great pest. In fact, in all the countries irrigated by the lower waters of the Danube, this fly, hardly larger than a flea, abounds; and it is said that in Hungary cattle and sheep have been destroyed by hundreds owing to the tortures they have suffered from these insects. The little flies creep into the eyes, nose, and ears of their victims, and there gorge themselves with blood, driving the poor beasts to the verge of madness by the intolerable irritation of their bites.



COLUMBATSCH FLY.
(Enlarged.)

The second family of the group (*Bibionidæ*) contains the well-known St. Mark's fly (*Bibio marci*), a large, black, hairy, slow-flying insect, common in spring, and taking its name from its being frequently seen in numbers on or about St. Mark's Day. The two sexes differ greatly in many respects, the male having the wings clear, whereas those of the female are dusky; again the eyes in the male are so large that the entire head seems to be composed of them, but in the female these organs are small and wide apart. This distinction, however, although not usually in so pronounced a form, is observed between the two sexes of many flies. The eggs — in number amounting to about one hundred and fifty — are laid on the ground among vegetable or animal débris, on which the larvæ subsequently feed. In the grub the head has neither eyes nor recognizable antennæ, but the mouth parts are distinct; the body consisting of twelve segments, each of which is surmounted by a row of bristles. After passing the winter in the soil in an immature state, the larvæ ascend to the surface in the spring, and take on the pupal stage, from which, after about a fortnight's time, the perfect insects emerge.



ST. MARK'S FLY.
(Natural size, with enlarged figure of larva and pupa.)

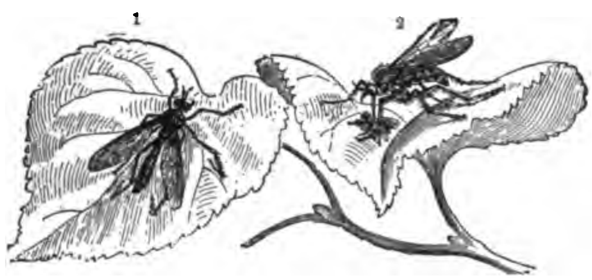
Horseflies or Breeze Flies Although related to the gnats and midges by the nature of the slit through which the pupa makes its escape from the larval skin, and consequently referred to the section Orthorrhapha, the flies of this family approach those of the second section in the shortness of their antennæ, and since all the Diptera with short antennæ were formerly termed the Brachycera,— as opposed to Nematocera,— these and the remaining families of the suborder are often grouped together as Orthorrhapha Brachycera. Although the horseflies (*Tabanidæ*) are often termed gadflies, the latter name is proved by Anglo-Saxon literature to have been originally applied to the *Œstrus* group of the *Muscidæ*. Horseflies are distributed all over the world, and vary but little in outward form, usually having large, fat bodies, and being generally of a dull reddish-brown color. They are all bloodsuckers, and the mouth parts — which have been described at the commencement of the chapter — attain a high degree of perfection as piercing instruments. A common representative of the family in England is the so-called clegg (*Hæmatopota pluvialis*), a grayish insect which has a habit of pitching quietly upon the hands or face, and inflicting a sharp prick almost before the victim is aware of its presence. Fortunately, however, it is easily killed, for, instead of taking flight, it generally stays where it has settled, and allows itself to be crushed. A larger though scarcer British species is the great horsefly (*Tabanus bovinus*), the female of which sucks the blood of large mammals, such as horses, asses, and cattle. The males always frequent flowers; and the larvæ in form and habits show considerable resemblance to those of the daddy long-legs, living in the soil and feeding upon the roots or grasses. In this way they spend the winter, reaching maturity in May, when they pass into the pupa stage, the fully-formed insect appearing in June. In India these insects are known as elephant flies, for even the thick hide of an elephant affords no protection against their sharp needle-like jaws. Judging from the account of a resident, horseflies are a terrible plague in Florida. "Cows, horses, and mules have a wretched time in the summer, when they are eaten alive, and come home with the blood running down them. When driving, we used to spend all our time killing these soft, fat-bodied insects, which die at the least touch — in fact, the commonest kind never seem in any case to live more than twenty-four hours, and those which come into the houses are always dead the next morning. Their sting is really painful. I remember one day, when walking through the flat woods, suddenly feeling something like a pin running into my arm, and, on looking down, found it to be an extra big horsefly. The arm was most tender for days after, feeling as though badly bruised, and was so much swollen as to make it quite a difficult matter drawing any sleeve over it. The 'coachman fly' [doubtless one of the family *Asilidæ*] is said to feed on the horseflies; and will sit through a whole drive on the collar, or some other part of the harness, or even on the steed itself, in order to pounce on the insects as they settle. The curious thing is that the horses seem to know the difference, for directly a horsefly comes, even if it

GREAT HORSEFLY WITH SIDE VIEW OF HEAD. (Natural size.)

does not sting, they become restless, tossing their heads, and lashing with their tails, but the 'coachman' may rest on any part of them for any length of time, and never be interfered with, or driven off."

Robber Flies, etc.

The flies of the family *Asilidæ* are generally of a somewhat slender build, the body being long and parallel sided, while the legs and wings are long and strong. All are provided with a short, powerful, piercing proboscis, and prey upon insects of various kinds, often seizing and carrying off butterflies, much larger than themselves. The general form of the members of this family is shown in Fig. 1 of the annexed illustration, representing *Dioctria oelandica*, a species from the island of Oeland, off the coast of Sweden, with a shining black body, and wings of the same color. Many species of the genus *Asilus* are found in Britain, but the largest and handsomest of all is the hornet robber fly (*A. crabroniformis*), measuring upward of an inch in length, and of a yellowish color variegated with black, there being four stripes of the latter color upon the thorax, and a broad transverse band across the base of the abdomen. Some of the tropical members of the family are far larger, those belonging to the genus *Mydas* from South America, being scarcely surpassed in dimensions by any member of the order. The fly represented in Fig. 2 of the illustration is the tessellated empis (*Empis tessellata*), belonging to the family *Empidæ*, the species of which are predaceous like the *Asilidæ*, and resemble them in form, but differ in certain structural details which need not be dwelt upon. The tessellated empis — the largest member of the group found in Britain — is ashy gray in color, and has its abdomen ornamented with a chessboard pattern. As Dallas expressed it, "when paired, the females of this and of many other of the larger species of the family are always found to be busily engaged in sucking out the juices of some other insect. It seems probable that the male seizes the opportunity of his intended partner being thus occupied to make his advances; if her mouth were free he would in all likelihood himself fall a sacrifice to her voracity."



ROBBER FLIES.
1. *Dioctria oelandica*; 2. *Empis tessellata*. (Natural size.)

Bee Flies

The families of short-horned, straight-seamed flies hitherto considered resemble each other in the fact that the larvæ live in the earth, and feed upon the roots of grass or other vegetable matter, while the adults prey upon other animals, whose blood they suck. But in the bee flies (*Bombyliidæ*) — so called from the likeness in hairiness and shape they present to humblebees — the larvæ, so far as known, live parasitically on other insects, attacking grasshoppers, caterpillars, etc., while the adults suck the juices of flowers. The genus *Bombylius* is represented in England by a small number of species, although in the tropics there are large numbers of forms. In all the thick, fat body is covered with long yellow hairs. The wings are powerful; and the head is furnished with a long

proboscis, which is thrust into blossoms while the insect (No. 8 on p. 3028) stays poised in mid-air, like a hawk moth when similarly occupied. The black and white bee fly (*Anthrax semiatra*) is mostly of a black tint, and clothed with hair of the same color; but the hairs on the front part of the thorax and abdomen take a yellowish tinge, the wings, as shown in the illustration, being black in the basal half but clear elsewhere. These insects may be seen on the wing in dry, sunny spots, stopping from time to time to suck a flower, or rest upon a stone, and seeking for the cells of solitary bees wherein to deposit their eggs. The left-hand figure shows the cocoon of one of these bees, with the pupa case, from which the fly on the right has just emerged, protruding from it. For the last family of this section (*Stratiomyidæ*) the common *Stratiomys chamæleon* may be taken as the type. This is a rather large insect, with a short broad abdomen, variegated at the sides with pale spots; the sides of the face and the posterior part of the upper surface of the thorax being also yellow. The antennæ are longish, and the hinder part of the thorax is armed with a pair of spines. The females, which may be seen on the wing in the neighborhood of marshes, ponds, and ditches, lay their eggs on the leaves of water plants, and the larvæ spend their time wriggling about in a helpless way. In these larvæ the body consists of twelve segments, is somewhat depressed, pointed at each end — though more so toward the tail than the head — and covered with a tough blackish-brown skin. The head is small and pointed, and the retractile tail segments are furnished at the tip with a breathing orifice surrounded by a circlet of barbed hairs. By means of these the larva is enabled to suspend itself from the surface of the water, hanging vertically downward with the orifice just above the water's level, and is also able by the folding in of the hairs to take a bubble of air below the surface when it sinks to the bottom. The larvæ feed on such particles of matter as they find in the water; and when ready to pass into the pupal stage creep to the land, and take refuge beneath a stone, or in some other place of safety. The development of the pupa and perfect insect takes place only in the front part of the larval skin. A curious choice of habitat for her young on the part of some flies belonging to this family has been recorded from Wyoming. These larvæ were found in a cup-shaped depression at the top of a cone about twenty inches high situated a few feet from a large sulphur mound, under which the boiling water could be heard. Through small apertures in the bottom the hot water rose and filled the cup. It was in this that the larvæ were found; and it is estimated that the temperature of the water was only twenty or thirty degrees below boiling point.

BLACK AND WHITE BEE FLY, WITH PUPA SKIN PROTRUDING FROM COCOON OF BEE.

FEMALE OF *Stratiomys chamæleon*.

CIRCULAR-SEAMED FLIES — SUBORDER **Cyclorrhapha**

This suborder, which is characterized by the circumstance that the pupa escapes from the larval skin through a circular aperture formed by the pushing off of the head end, contains the majority of ordinary flies. It is divisible into two sections, the first of which includes those that present the normal method of development, the young being hatched from eggs laid by the mother, although very rarely the eggs hatch immediately before being laid. The second embraces those in which the young are retained within the parent's body, and nourished at its expense until the pupa stage is reached. The flies of the last category are for this reason generally called Pupipara.

Hover Flies

The family *Syrphidæ* includes a number of species which, although differing considerably in external form, may be distinguished from other members of the suborder by the presence of the so-called spurious vein in the wing — a vein lying between the third and fourth longitudinal veins, and crossing the short transverse vein (marked in the figure on p. 3011) which unites them. They also bear considerable superficial resemblance, both in color and shape, to various bees and wasps. The best-known types are the hover flies (*Syrphus*), drone flies (*Eristalis*), and humblebee flies (*Volucella*). The hover flies of the genus *Syrphus*, which with their black and yellow bands mimic wasps, are so named on account of their habit of hovering in flower gardens in summer, darting from blossom to blossom, and often sustaining themselves poised in mid-air, after the manner of a hawk. The females lay their eggs singly on leaves and stems infested with plant lice; and the larvæ devour numbers of these pests, seizing them in a most voracious manner, sucking them dry, and rejecting the empty skins.

HOVER FLY (*Syrphus seleniticus*).

1. Fly; 2. Fly hovering; 3. Larvæ devouring plant lice on leaf; 4. Larva; 5, 6. Different views of pupa. (4, 5, 6, enlarged; the rest natural size.)

Drone Flies

Like the hover flies, drone flies (*Eristalis*) frequent flower gardens, where they may be seen in numbers on various blossoms. As their name indicates, these flies resemble honeybees, the likeness being so close that it is difficult to persuade an uninitiated person that they may be handled with impunity. The resemblance, which is enhanced by the ceaseless twitching of the abdomen, appears indeed to be more deeply seated than might at first be supposed, for spiders, which recognize

their prey by touch and not by sight, treat the drone flies with caution. Thus a bluebottle fly placed in a web of the field spider was immediately and without hesitation seized and devoured, although a humblebee was avoided by the spider, which — evidently fearing to come to close quarters — let out a thread, and rushing round and round its victim at a distance, succeeded in winding it up, and then approaching, inflicted a bite which soon put an end to the insect's struggles. When a drone fly was thrown into the web, the spider darted at it as before, but as soon as it touched the fly with its fore-legs, recoiled, as if in alarm, then returning to the attack dealt with the harmless victim just as it had previously acted with the humblebee. The larvæ of the drone flies live mainly in ditches and feed upon decaying organic matter, and are commonly known as rat-tailed maggots, on account of the long tail-like appendages at the hinder end of the body. With this flexible and telescopic tail, traversed by tracheal tubes opening at its tip, the maggot is able to breathe while below the water, by keeping the tip of its tail above the surface, where it is supported by the rosette of hairs round the extremity. The eggs of drone flies are also laid in dead carcasses and other refuse, and it is now believed that the legend of the ox-born bees of the ancients is traceable to this habit of the fly, in conjunction with its striking resemblance to the honeybee. The belief that honeybees are produced by spontaneous generation from carcasses of dead animals has prevailed for more than two thousand years, but according to Osten Sacken, "the original cause of this delusion lies in the fact that a drone fly (*Eristalis tenax*) lays its eggs upon the carcasses of animals, that its larvæ develop within the putrescent mass, and finally change into a swarm of flies, which in their shape, hairy clothing, and color look exactly like bees, although they belong to a totally different order of insects." Scarcely less interesting than the drone flies are the species of *Volucella*. These large flies (p. 3028, No. 9) mimic humblebees in color and form, and it was long supposed that the females were thus enabled with impunity to enter the nests of humblebees and lay their eggs among those of the proper owners. But although it is true that the eggs of the *Volucella* are laid and the larvæ reared inside the nests of various Hymenoptera, it has been ascertained that the species which resemble humblebees visit for the same purpose the nests of wasps, to which the flies bear no particular resemblance. And it is hardly credible that the wasps give access to the flies under the delusion that they are members of the community, as was conceivable in the case of the bees. We are compelled therefore to conclude that the flies are allowed by the bees and wasps to come and go without interference for some reason apart from the resemblance that exists between the two sets of insects. It is, of course, possible that the similarity offered by the flies to bees and wasps is more deeply seated than was supposed, and affects such senses as touch or smell, or some other unknown sense, but there seems no evidence to justify this supposition; and if the maggots of the flies feed on the larvæ of the bees or wasps, we are not yet in a position to offer an explanation of the phenomenon. If they play the part of scavengers, clearing the hive of waste matter, the reason for the admittance of the flies becomes clear.

Closely resembling many of the *Syrphidæ* in their banded coloration, which imparts to them a wasp-like aspect, the members of the family *Conopidæ* may be

recognized by the absence of the spurious vein in the wings, and also by their broad heads, of which the fore part is produced into a conspicuous prominence bearing the long antennæ. Like the horseflies, the *Conopidæ* in the adult stage frequent flowers, but they lay their eggs in the bodies of various Hymenoptera, like bees and wasps, and also in crickets and other Orthoptera. Here the eggs hatch and the larvæ feed upon the living tissues of their prey, and here they undergo their metamorphosis, although they do not invariably quit the place of their development upon the death of the victimized host. Taschenberg, for example, found the pupa of *Conops vittatus* emerging from the abdomen of a humblebee which had been for six months in his collection. The *Conopidæ* are widely distributed, and especially abundant in the Tropics. Bates gives an account of the habits of a species which he noticed hovering over the armies of foraging ants. These ants, he says, "are accompanied by small swarms of a kind of two-winged fly, the females of which have a very long ovipositor, and which belongs to the genus *Stylogaster*. These swarms hover with rapidly vibrating wings, at a height of a foot or less from the soil over which the ants are moving, and occasionally one of the flies darts with great quickness toward the ground. I found that they were not occupied in transfixing ants . . . but most probably in depositing their eggs in the soft bodies of insects which the ants were driving away from their hiding places. These eggs would hatch after the ants had placed their booty in their hive as food for their young."

Typical Flies

The family *Muscidæ* embraces a large and varied assortment of species, of which house flies and blowflies are well-known examples. The characteristic structure of the wings may be seen by referring to the figure on p. 3011. The proboscis is adapted for sucking, and usually ends with two fleshy lobes. The flagellum of the antennæ is generally plumed with hairs on both sides, though sometimes, as in the tsetse, the hairs are restricted to one side, while in the spiny flies it may be naked. The relative size of the three basal segments of the antennæ varies in different genera, but usually, as in the blowflies, the house flies, and the tsetse, the third segment is at least three times the length of the second (see *b* in figure on p. 3030, and 10 in that on p. 3028). It may also be mentioned that the upper surface of the thorax is marked with a transverse suture, and that the feet are furnished with a pair of adhesive pads (11 in the figure on p. 3028). The family is divided into several subfamilies, and these may be grouped in two sections, based upon the presence or absence behind the wings of a membranous scale which, when present, covers the *halteres* or balancers. The subfamilies that possess this scale are termed the calypterate *Muscidæ;* while those that are without it are in contrast called the acalypterate *Muscidæ*. Taking the calypterate *Muscidæ*, we begin with the subfamily *Muscinæ*, of which the house fly (*Musca domestica*) is the typical representative. This species may be found during summer in numbers in every house, crawling up the windowpanes, flying in companies about the middle of the room, or creeping about the table in search of food. It is the unwelcome companion of man in every country, following him in his travels, taking up its residence with him wherever he may choose to settle, and resisting equally well the cold of northern latitudes and the heat of tropical climes. For the most part, the eggs are laid and the larvæ undergo their development in excrement;

but the choice of the female does not seem to be always restricted to matter of this sort, since she sometimes selects meal, bread, or fruit, for the purpose. These flies are liable to the attacks of a parasitic fungus (*Empusa muscæ*) which causes their death, and in autumn it is not uncommon to find their bodies killed by this means, with the abdomen much distended, and showing the soft membrane between the segments. The common bluebottle or blowfly (*Calliphora erythrocephala*) is too well known to need description. One of the most noteworthy features connected with this fly is the extraordinary keenness of the sense — perhaps smell, which enables it to discover the whereabouts of carcasses, however small, or of particles of meat. In these it hastens to lay its eggs; and in a longer or shorter time, according to temperature, the eggs hatch, and the larvæ, feeding upon the meat, rapidly grow until they reach maturity and pass into the pupa stage. Many persons believe that bluebottles are full-grown examples of the house fly, and when informed that such is not the case, and that these insects after reaching the winged stage are incapable of growth, point out that bluebottles vary greatly in size, and ask what may be the explanation of the difference. The answer is, that the size of the bluebottle in its final stage depends upon the size of the maggot before pupating, and the size of the maggot upon the amount of nourishment it is able to obtain before its supply of food was exhausted. In any given case, when the supply is limited, the maggots that are the first to hatch will get more food than those that appear later, and in consequence, when the whole of it is exhausted, will have attained a greater length and fatness than the others, and thus become converted into larger flies. Or, again, if three or four hundred eggs be laid in a dead mouse and the same number in a dead rabbit, it is clear that in the former case the supply of food will be smaller for each larva, and will sooner come to an end than in the latter.

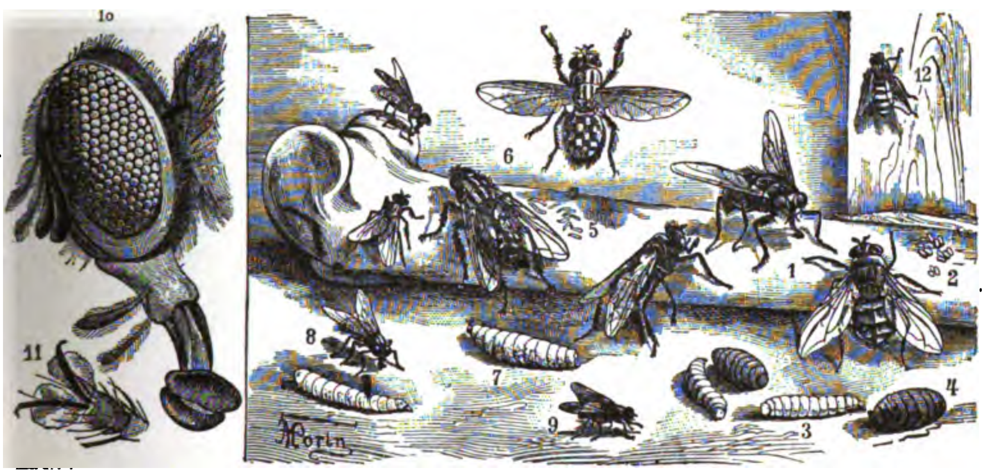
The gray flesh fly (*Sarcophaga carnaria*) is a handsome species, measuring in the female half an inch in length. Seldom entering houses, it is not uncommon in the open country, where it may be seen basking in the hot sun upon stones or walls. Its prevailing color is pale slate gray, variegated on the thorax with black bands, and the abdomen with square black spots, set corner to corner like the squares of a chessboard. A noteworthy fact connected with this species is that the eggs hatch within the parent before being laid, so that the young are born alive; they feed upon decaying animal and vegetable matter. The blowflies belonging to the genera *Calliphora* and *Lucilia*, respectively known as the bluebottle and greenbottle flies, as a general rule deposit their eggs upon dead animal matter. This, however, is by no means always the case, there being many instances on record of the laying and hatching of the eggs upon living animals. Thus it is by no means uncommon for sheep to be attacked in this way by a greenbottle fly (*L. silvarum*). On this subject, Mr. Reeks writes that "these flies deposit their eggs in the wool of sheep, generally about the root of the tail or behind the shoulders, anywhere, in fact, where the wool is most greasy. The larvæ of these flies are most troublesome to shepherds in the latter part of May and June, until the sheep are sheared, and much later in the summer with lambs, when they should be dipped in a preparation of arsenic and soft soap." Toads and frogs also seem to be fre-

INSECT LIFE IN SUMMER.

1. Common Wasp; 2. 3, Honeybees; 4. Hairy-legged Bee (*Dasypoda*); 5. Wasp (*Pompilus*); 6. Stone Humblebee; 7. Common Humblebee; 8. Bee fly (*Bombylius*); 9. Humblebee Fly (*Volucella*); 10. Spiny Fly (*Tachina*); 11. Noctuid Moth (*Anarta*); 12. 13. Field Tiger Beetle, crawling and flying; 14. Wood Tiger beetle; 15. Rose Beetle (*Cetonia*); 16. Dung Beetle (*Typhœus*); 17. Field Cricket; 18. Grasshopper (*Stenobothrus*).

(3028)

quently selected as objects of attack on the part of these flies. In one case the eggs of a greenbottle fly were laid on a toad's back, and the larvæ upon hatching migrated into its eyes. In other cases the laying of the eggs and migration of the larvæ have not been actually observed, but toads have been found with their nostrils infested with maggots; and it is possible that the latter may have effected an entry from the outside, as described above. Mr. Guthrie, who noticed the occurrence of the larvæ of a bluebottle (*Calliphora*) in the nostrils of toads, writes that "it is probable that the number of toads is largely kept under by those means. In 1872 toads were remarkably plentiful in the neighborhood of Tenby, South Wales, and I noticed that the disease was very prevalent among them. In the following year scarcely any could be found, and I saw none diseased." Cases are also on record of the death of lizards from maggots of blowflies, which testify to the extraordinary vitality of the latter. In one instance a gecko fed on bluebottles was found to have



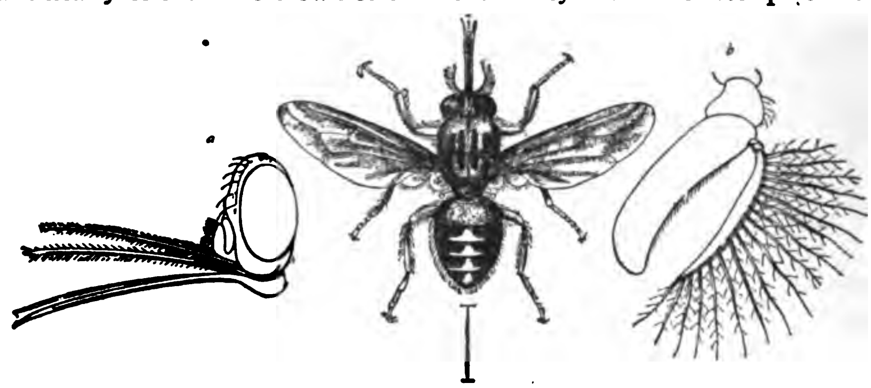
GROUP OF FLIES AND THEIR GRUBS.

1. Blowfly; 2. Eggs; 3. Larvæ; 4. Pupa; 5. Newly-born larva of gray flesh fly; 6. Gray flesh fly; 7. Adult larva of the same; 8. House fly and larva; 9. Sharp-mouthed fly; 10. Head of house fly; 11. Foot of gray flesh fly; 12. Carcass of house fly killed by fungus growth. (10, 11, enlarged; the other natural size.)

the whole abdominal region greatly distended. It soon afterward died, and on dissection its intestines, lungs, and liver were found to be almost entirely destroyed by maggots, whose presence was naturally attributed to eggs from gravid female bluebottles, which had been swallowed as food. In another case, some lizards fed on the living maggots of the bluebottle died in consequence of the attacks on their internal organs by their intended food. Far more important are the cases of infection of human beings; the resulting sickness, which often entails great suffering, and may end in death, being known as *myiasis*.

The sharp-mouthed fly (*Stomoxys calcitrans*), represented in 9 of the figure on p. 3028, closely resembles the house fly in size, shape, and coloring, but may be recognized by its sharp, horizontally projecting proboscis, and also by the flagellum of the antennæ being hairy upon one side only. It is less often seen in houses than the house fly, although occasionally paying them a visit, especially if there be

stables in the vicinity. By means of its proboscis this fly pierces the skin of cattle and horses, or even of man, and gorges itself on the blood. Its eggs are laid in the excrement of the cattle on which it feeds. Resembling *Stomoxys* in habits and in the structure of its antennæ and mouth parts, the tsetse fly (*Glossina morsitans*) of Equatorial Africa, although barely equaling a blowfly in size, is one of the greatest pests to domestic cattle, as the following accounts amply testify. As shown in the annexed illustration, the proboscis of this fly is long and prominent, and the antennæ (*b*) are peculiar in that the third segment is very long and produced almost as far as the apex of the flagellum, which is furnished with barbed hair along its outer surface only. Writing of the tsetse, Livingstone says that "we had come through another tsetse district by night, and at once passed our cattle over to the northern bank, which, though only fifty yards distant, was entirely free from the pests. This was the more singular that we often saw natives carrying over raw meat with many tsetse upon it. This insect is not much larger than the common house fly, and is nearly of the same brown color as the honeybee. The after part of the body



TSETSE FLY (enlarged).
a. Side view of head; *b*. Antenna.

has three or four yellow bars across it. It is remarkably alert, and evades dexterously all attempts to capture it with the hand at common temperatures. In the cool of the mornings and evenings it is less agile. Its peculiar buzz when once heard can never be forgotten by the travelers whose means of locomotion are domestic animals, for its bite is death to the ox, horse, and dog. In this journey, though we watched the animals carefully, and believe that not a score of flies were ever upon them, they destroyed forty-three fine oxen. A most remarkable feature is the perfect harmlessness of the bite to man and wild animals, and even calves so long as they continue to suck the cows, though it is no protection to the dog to feed him on milk. The poison does not seem to be injected by a sting, or by ova placed beneath the skin, for, when the insect is allowed to feed freely on the hand, it inserts the middle prong of the three portions into which the proboscis divides somewhat deeply into the true skin. It then draws the prong out a little way, and it assumes a crimson color as the mandibles come into brisk operation. The previously shrunken belly swells out, and, if left undisturbed, the fly quietly departs when it is full. A slight itching irritation follows the bite. In the ox the immediate effects

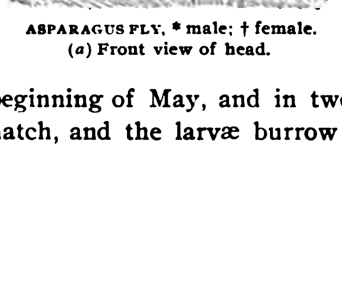
are no greater than in man; but a few days afterward the eyes and nose begin to run, the coat stares, a swelling appears under the jaw, and sometimes at the navel; and though the poor creature continues to graze, emaciation commences, accompanied with a peculiar flaccidity of the muscles. This proceeds unchecked until, perhaps months afterward, purging comes on, and the victim dies in a state of extreme exhaustion. The animals which are in good condition often perish soon after the bite is inflicted with staggering and blindness, as if the brain were affected. Sudden changes of temperature produced by falls of rain seem to hasten the progress of the complaint, but, in general, the wasting goes on for months. When the carcass is opened, the cellular tissue beneath the skin is found injected with air, as if a quantity of soap bubbles were scattered over it. The blood is small in quantity, and scarcely stains the hands in dissection. The fat is of a greenish-yellow color, and of an oily consistence. All the muscles are flabby, and the heart is often so soft that the fingers may be made to meet through it. The lungs and liver partake of the disease. The stomach and bowels are pale and empty, and the gall bladder is distended with bile. These symptoms seem to indicate poison in the blood, the germ of which enters when the proboscis is inserted. The mule, ass, and goat enjoy the same immunity from the tsetse as man and the game. Many large tribes on the Zambezi can keep no domestic animals except the goat, in consequence of the scourge existing in their country. Our children were frequently bitten, yet suffered no harm; and we saw around us numbers of zebras, buffaloes, pigs, palas, and other antelopes feeding quietly in the very habitat of the fly. There is not so much difference in the natures of the horse and zebra, the buffalo and ox, the sheep and the antelope, as to afford any satisfactory explanation of the phenomenon." With the gradual spread of civilization, it might be supposed that the ravages of this pest would become lessened; but this does not appear by any means to be the case. Writing in 1881, Mr. Selous remarks that "nowhere does this virulent insect exist in such numbers as to the westward of the Victoria Falls, along the southern bank of the Zambezi and Chobe. It is usually found in great numbers near the rivers, becoming scarcer and scarcer as one advances inland, till at a distance of a few miles it disappears, except in some particular patches of forest. Along the water's edge they are an incredible pest, attacking one in a perfect swarm from daylight till sunset; and without a buffalo or giraffe tail to swish him off, life would be unendurable. . . . About one in every ten bites (that perhaps touches a nerve) closely resembles the sting of a wasp or bee, as it will cause one, when seated to spring up as if pricked with a needle. . . . I think that this plague of the tsetse flies along the Chobe and Zambezi is due to the enormous numbers of buffaloes that frequent their banks, as they always seem very partial to these animals. The bite of this remarkable insect, as is well known, though fatal to all kinds of domestic animals, is innocuous to every species of game and to man. A general belief exists that among domestic animals, the donkey, dog, and goat are exceptions to this rule; but this is a mistake, for I have seen all three die from the effect of its bites." The genus to which the common tsetse belongs is represented in South Africa by several species, all of which seem to be similar in habits. It ranges from Somaliland in the east and the Congo in the west, southward as far as the

Limpopo. Fortunately, it is not universally distributed throughout the country, being somewhat local in its distribution, and inhabiting definite tracts of land, corresponding with the beds of rivers, from which it does not appear to spread to any great distance.

Another group of flies constitutes the subfamily *Tachininæ*, of which the best-known examples are the spiny flies (*Tachina*), so called on account of the thickness of the bristles with which their bodies are clothed. Of stout and robust build, these flies present a great resemblance to blowflies and their allies, but have the bristles of the antennæ naked, or feathery only at the base, and the scales covering the balancers of larger size. The larvæ, like those of the Conopidæ, live parasitically upon other insects, such as beetles, grasshoppers, and caterpillars. The great spiny fly (*Echinomyia grossa*), rather a local species, is the largest representative of the family found in Britain. It is about two-thirds of an inch long, with a short, broad, oval abdomen; the shining black of its body being relieved by the reddish-yellow color of the head and the base of the wings. The allied species (*E. ferox*) represented in the illustration is brownish, with the abdomen tinted with red at the sides. Belonging to the same subfamily is the Australian fly, *Rutilia*, remarkable among the order for being ornamented with bright metallic-green spots. By reason of their external form and general coloring the flies of the subfamily *Anthomyinæ* appear to the casual observer to be nothing but ordinary house flies; but they may be distinguished from the latter by the absence of the apical transverse vein on the wing (marked *d* on the figure of the fly's wing on p. 3011). The scales, moreover, which cover the *halteres* are very small, and lead up to the condition found in those flies in which they are absent. The larvæ, which differ from those of the house flies and blowflies in being covered with spines, live on plants of various kinds, those that have attracted the most attention being the species that attack cultivated vegetables, such as onions, cabbages, lettuces, radishes, and the like.

SPINY FLY (*Echinomyia ferox*), WITH LARVA AND PUPA. (Natural size.)

Those members of the family having no scales covering the balancers and assigned to the subfamily *Trypetinæ* are generally of small size, many being very obnoxious on account of the damage inflicted by their larvæ on various marketable vegetables. Of the numerous species it is only possible to notice a few. The first is the painted-winged asparagus fly (*Platyparea pœciloptera*), which, as its name indicates, has variegated wings, and attacks asparagus. The male is smaller than the female, as shown by the length of the lines in the figure, and the latter sex may be recognized by the possession of a long ovipositor, by means of which she deposits her eggs between the scales of the head of the asparagus. The laying takes place about the beginning of May, and in two or three weeks, according to the season, the eggs hatch, and the larvæ burrow into the stalk of the plant. In a fortnight or so the



ASPARAGUS FLY, * male; † female. (*a*) Front view of head.

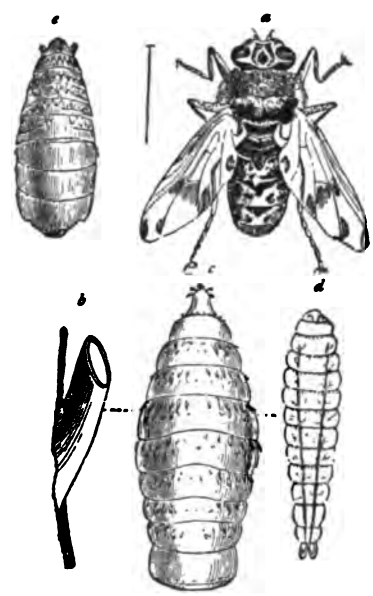
latter reach maturity, and, after passing through the pupa stage, develop into flies toward the end of June. Many more or less nearly-allied species are found in England and other countries, but it will suffice to indicate a few of the more important. Of these the cherry fly (*Spilographia cerasi*) and the olive fly (*Dacus oleæ*) devour in their larval stages the fruits after which they are named; while the various species of the genus *Ceratitis* similarly attack the orange. Recently *C. capitata* was very destructive to the mandarin oranges in Malta, and seems to have been first introduced into the island about twenty years ago. This fly is lively and hardy, as shown by the fact that a specimen kept under a glass shade without food maintained its activity for twelve days. When egg laying, the female chooses the side of the fruit exposed to the sun, where it perforates the rind so that the larvæ upon hatching start at once to devour the nutritious food. The infected fruit drops to the ground, and the larvæ when mature pass out to become pupæ beneath the earth. Besides oranges and other acid fruits, peaches and melons are attacked by this fly. The annexed figure represents another of these injurious little insects (*Chlorops tæniopus*), a shining yellow fly variegated with black bands. This species and its allies, which are most destructive in the larval stage to cereals and grass, much resemble in the cycle of their development the before-mentioned Hessian fly. Allied to the preceding in structure and habits are the members of the subfamily *Ortalinæ*, containing the genus *Ortalis* and others. A curious representative from the Malay Archipelago, known as the stag-horn fly (*Elaphomyia*), takes its name from the development of the sides of the head into large branching horns. This, however, is only a sexual characteristic, and confined to the male. Finally, the small black fly (*Piophila casei*), known in the grub stage as the cheese hopper, belongs to that group of *Muscidæ* in which there are no scales to cover the balancers.

Chlorops tæniopus, with figure showing side view of head. (Much enlarged.)

GADFLIES AND BOTFLIES — Family *ŒSTRIDÆ*

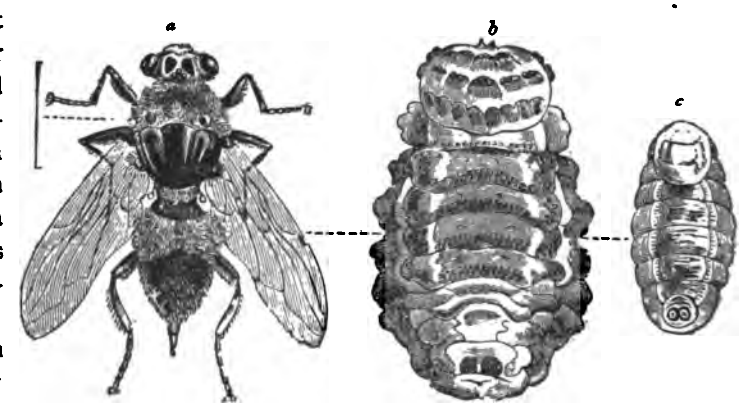
The flies of this family are mostly of large size, and many present superficial resemblance to various kinds of bees. In structural characteristics they are nearly allied to house flies, but the head is larger and broader and the mouth parts are reduced. In the larval stage gadflies infest, either as internal or external parasites, various mammals, but since those that attack domestic cattle have been more thoroughly studied than the others, attention will mainly be directed to three of the best-known forms, namely, those that infest respectively horses, oxen, and sheep. The horse botfly (*Gastrophilus equi*), which resembles the honeybee in size, color, and form, lays its eggs on the skin of horses, asses, and mules, which seem to have an instinctive dread of the insect. It has been noticed, moreover, that the gadfly instinctively selects for the purpose a spot that is well within reach of the

quadruped's mouth. The reason for this, although not at first very obvious, becomes clear when it is understood that the larval fly can only obtain its proper nourishment in the alimentary canal of its host. As soon as the maggot emerges from the egg it starts to irritate the horse's skin. Thereupon the horse, to remove the irritation, licks the infested spot and swallows the maggots, which then attach themselves by means of their hook-like mandibles to the inner wall of the stomach or œsophagus, making little excavations, and nourishing themselves by sucking up the secreted mucus. Here in perfect security they live and grow for about a year; after which, when nearly full grown, they enter the intestine and pass out of the body with the excrement. Falling to the ground, the maggots bury themselves in the soil and enter upon the pupal stage. In favorable weather the perfect insect is produced from the pupa in about six weeks. The ox bot or ox warble (*Hypoderma bovis*) deposits its eggs in the hair of the skin of cattle, and the maggots, after hatching, burrow through the skin and take up their lodging in the tissues beneath, where in course of development they give rise to the large tumors known as warbles, each of which opens to the exterior by means of a small aperture. In these tumors the maggots remain for ten or eleven months until practically full grown, when, quitting their host, they fall to the ground, bury themselves, and in the course of a month or six weeks emerge from the pupa stage as fully-developed flies. The species most commonly met with in England is not *H. bovis* but *H. lineatum*.



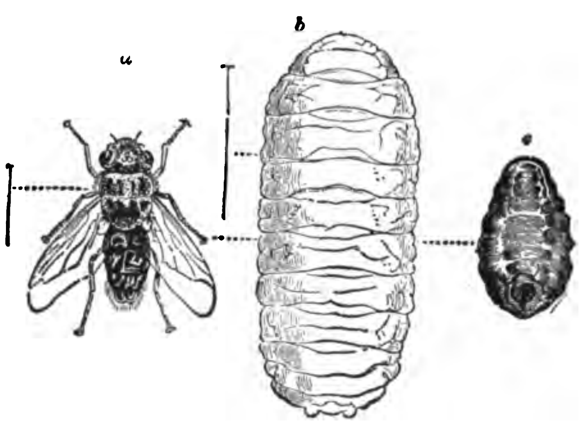
DEVELOPMENT OF HORSE BOTFLY.
a. Adult fly; *b.* Egg attached to a hair; *c.* Mature larva; *d.* Newly-hatched larva; *e.* Pupa. (All enlarged.)

It can be easily understood from the fact that since no fewer than four hundred maggots, each growing to an inch in length, have been known to infest a single beast, the loss occasioned by the attacks of this fly is considerable. It has been estimated, indeed, by Stratton, that in the United Kingdom alone a loss of something



OX WARBLE FLY AND ITS DEVELOPMENT.
a. Fly; *b.* Larva; *c.* Pupa—the latter from the lower side. (All enlarged.)

like $40,000,000 per annum is sustained. The mischief begins in the summer, when the cattle gallop about in terror in their vain efforts to escape the flies seeking to deposit their eggs upon them. This causes waste of milk and damage to health. Then there is the damage to the meat by the destruction of the tissue just under the hide, resulting in what butchers call licked meat or jelly. And lastly, there is the evidence of tanners as to the damage to hides; one estimate given by a firm putting the loss on hides sold at two markets in Birmingham during seven weeks at $2,700; while a Nottingham authority reckons the loss in that town at $7,500 to $10,000 per annum. The sheep botfly (*Œstrus ovis*) lays its eggs in the nostrils of sheep, and the maggots after being hatched pass up the nasal passages and enter the chamber in the bones of the forehead, where they nourish themselves on the mucus to which the irritation of their presence gives rise. The presence of these parasites, which are seldom fewer than seven or eight at a time, is most injurious to the infested animal, and gives rise to a sickness of a very serious nature. At the end of about nine months the larvæ reach maturity, and making their way again into the nostrils are expelled by the sneezing of their host, and reaching the ground bury themselves, and remain concealed until they emerge as perfect insects from the pupal stage. The three species above mentioned serve as types of the life histories of the entire family, which contains in addition a large number of genera and species infesting various kinds of animals. Even man himself is not exempt from their attacks, and all kinds of domestic cattle and beasts of burden, such as reindeer, camels, and elephants, are liable to be infested with them. Two notices of the occurrence of larvæ in human beings were published by John Howship in 1833. In both cases the larvæ, named *Œstrus humanus*, were extracted from tumors, the sufferer in one case being a soldier in Surinam, and in the other a carpenter in Columbia. In addition to the mammals mentioned, others, such as hares, rabbits, mice, and voles, often suffer from these parasites. Their larvæ have also been met with in birds and frogs. Schneider, for instance, states that two larvæ much resembling those of *Hypoderma* were obtained from under the skin of the head of a young sparrow, where they had produced two large hard tumors, and Krefft has given descriptions of specimens belonging to the genus *Batrachomyia* that were found living parasitically upon Australian frogs. The larvæ were situated between the skin and the flesh behind the drum of the ear, and could be squeezed out through apertures in the skin.



LIFE HISTORY OF SHEEP BOTFLY.
a. Adult fly; *b.* Larva from upper side; *c.* Pupa from under side. (All enlarged.)

FOREST FLIES — Family *HIPPOBOSCIDÆ*

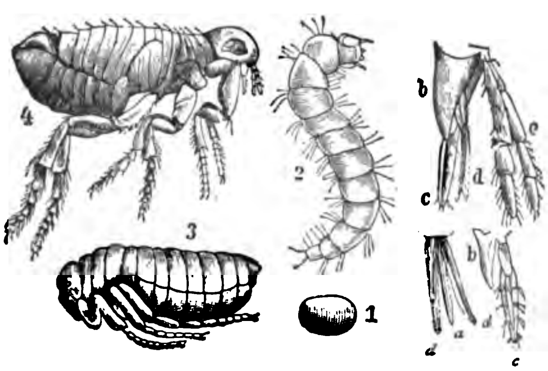
This family brings us to the second section (*Pupipara*) of the Cyclorrohapha, all the members of which are no less remarkable among flies for the strangeness of their appearance than for their method of development. They are all short and flat, with longish and powerful legs which enable them to run with great speed; some of them being entirely wingless, with the mouth parts much reduced; but in the mode of their development they are absolutely unique in the entire order. In the first place only a single young one at a time is produced, and this, instead of being laid in the egg stage, remains within the mother, nourished at her expense by means analogous to those which obtain in the higher mammels. When born, the young is either actually a pupa, or immediately assumes the pupa state, being motionless, without segmentation, and entirely protected by a horny shell, which imparts to it the appearance of the seed of a vetch. The members of this section, which are mostly parasitic on birds or mammels, are referable to three families. Of these, the forest flies are represented by several genera, all the members of which are parasitic upon mammals or birds, and are frequently spoken of as ticks. The species known from its abundance in the New Forest as the forest fly (*Hippobosca equina*) has the wings well developed. It infests horses and oxen, usually attaching itself to those parts of the body where the covering of hair is scanty. A second kind, known as *Ornithomyia avicularia*, occurring, as its name indicates, on birds of almost all kinds, also possesses a pair of fully-developed wings; but in another species, *Stenopteryx hirundinis*, which is found on swallows and about their nests, the wings are narrow and sickle-like and scarcely fitted for flight. A fourth species, the so-called deer tick (*Lipoptena cervi*), is provided with wings upon issuing from the pupa case; but after flying about for a time the insects settle upon deer, and drop their wings by fracturing them at the base. The last member of the family to be mentioned, the so-called sheep tick — which must not be confounded with the mite of that name — is entirely wingless from its birth. We thus get in this family a series of forms starting with the fully-winged forest fly and leading through the swallow tick with its wings reduced in size, and the deer tick which can cast its wings, to the sheep tick which has entirely lost these organs. The second family of the group, *Nycteribiidæ*, contains the single genus *Nycterbia*, the species of which live parasitically upon bats. All are wingless and have lost their compound eyes, but possess the balancers. The legs are long, powerful, and furnished with strong hooked claws, by means of which they cling to the hosts they infest. The bee louse (*Braula cæca*, G. on p. 3001), the type of the family *Braulidæ*, is a minute, blind, and wingless insect infesting honeybees; being found upon the workers, as well as upon the drones and queen, but seeming to have a preference for the two latter as hosts.

COMMON FOREST FLY.
(Enlarged.)

THE FLEAS — Family *PULICIDÆ*, etc.

The fleas, which by some are regarded as an order (Aphaniptera), may be considered to be aberrant flies; their mouth organs, which are adapted for piercing and sucking, being modified upon the same principles as obtain in the flies. They further resemble that group in undergoing a complete metamorphosis, but differ from the majority of flies in being destitute of wings. The group is divisible into two families. In the true fleas or *Pulicidæ* the body of the adult is strongly flattened from side to side, and thus, in conjunction with the smooth, hard, and nearly naked integument, enables the insect to swiftly traverse the hairy coating of its host. Some of the segments, however, are usually armed with strong backwardly-projecting spines. There are no compound eyes, but each side of the head is furnished with a simple eye; the legs being long, strong, and fitted for leaping. The eggs are laid about the floors of houses, kennels, etc.; and the larvæ, which are slender, worm-like creatures, devoid of legs, but furnished with a biting mouth, live on particles of decaying organic matter found in the dust of the places they infest. When adult, the larva, or maggot, is said to spin a cocoon within which the pupa state is passed. In addition to mankind fleas (*Pulex*) live parasitically upon other animals such as dogs, cats, badgers, pigeons, fowls, moles, hedgehogs, squirrels, etc. They are, moreover, even more abundant in tropical than in temperate countries. Tennent, for instance, says that in Ceylon "they may be seen in myriads in the dust of the streets, or skipping in the sunbeams which fall on the clay floors of the cottages. The dogs to escape them select as their sleeping places spots where a wood fire has been kindled; and here, prone on the white ashes, their stomachs close to the earth, and their hind-legs extended behind, they repose in comparative coolness, and bid defiance to their persecutors."

To the family *Sarcopsyllidæ* belongs the dreaded chigoe or jigger (*Sarcopsyllus penetrans*) of tropical countries. The adult female burrows beneath the skin of the foot, and shortly after effecting an entrance her body becomes swollen up with eggs, and grows to the size of a pea. At this stage she may be easily extracted, and as the young are not parasitic it is seldom that serious results ensue. According to Mr. W. H. Blandford, "the recorded distribution of the chigoe extends over tropical America and the Antilles, from 30° N. to 30° S., and in late years it has been exported in ballast to Africa, and has established itself in Angola, Loango, and the Congo." It also occurs in British Central Africa, where quite



COMMON FLEA AND ITS STRUCTURE.

1. Egg; 2. Larvæ; 3. Pupa; 4. Perfect insect; *a.* Labrum; *b.* Labium; *c.* Labial palpi; *d.* Mandible; *e.* Maxillary palpi.

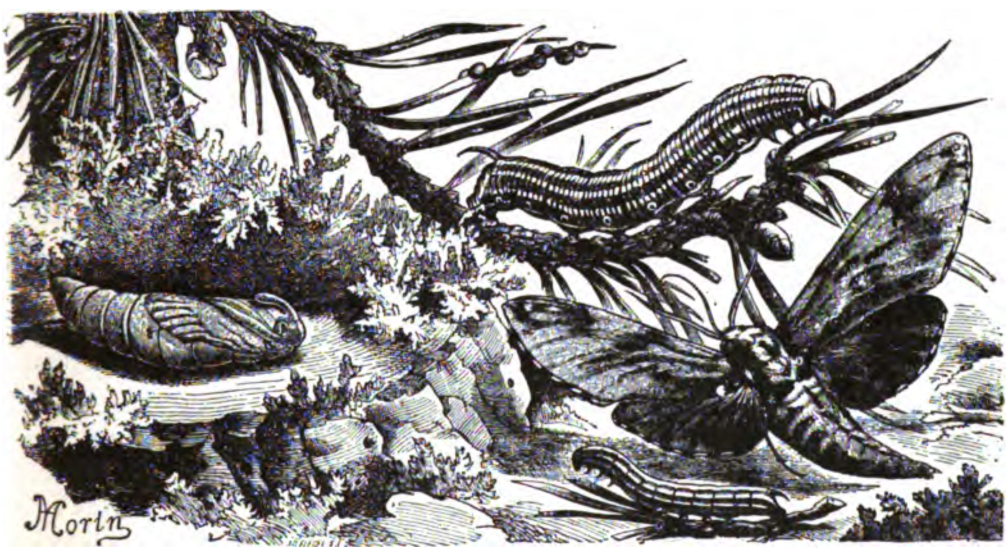
recently it occasioned much suffering among the natives, and, by laming the native postmen, caused delay in the transmission of mails. As in the case of the *Pulicidæ*, the fleas of this family do not confine their attentions to mankind. There is, for example, a genus known as *Vermipsylla*, which occurs in Turkestan, and is said to be very injurious to cattle; and Mr. Blandford has recently recorded a species from Ningpo in China, found buried in the ears of sewer rats. Speaking of the occurrence of the jigger in Florida, a correspondent writes that "the wooden houses are built on piles, and under them the sand is infested with jigger fleas. All dogs are attacked by them, and fowls and puppies frequently killed; in fact, sitting hens must regularly have their combs covered with lard and brimstone, and insect powder dusted over their wings, to keep them alive. These jiggers are very tiny and black, and do not hop like Old-World fleas, but, fixing themselves into the flesh, stick there, and are most difficult to remove. An English visitor who has once collected eggs in a Florida hen house, on a hot June day, will forever remember the result."

CHAPTER III

JOINTED ANIMALS — *continued*

INSECTS — *continued*

BUTTERFLIES AND MOTHS — Order LEPIDOPTERA



PINE HAWK MOTH WITH LARVÆ AND PUPA.

THE beautiful insects comprehended in the order to which the name Lepidoptera or scale wings has been given are familiar to the majority of readers without any lengthened introductory description. The butterflies or Rhopalocera and the moths or Heterocera, though they form two distinct sections of the order, cannot be divided by any hard-and-fast lines. They may generally be distinguished from one another by the manner of the folding of the wings at rest, or more precisely by the different character of the antennæ. The wings of the moths, too, are locked together by a tiny hook on the inner margin of one wing fitting into an eye on the inner margin of the other. The butterflies never possess this curious structure. The Lepidoptera are easily distinguishable from other orders of insects by the four ample wings, with more or less regular veins or nervures, clothed with the minutest, exquisitely-chiseled scales, of many shapes, and great variety of external chasing. These scales are but modified forms of hairs, broadened out, flattened and fashioned to cover the delicate membrane of the wing with an overlapping armament of

beauty. And it is to this wondrous sculptured dust, breaking up the rays of sunlight as it plays upon the surface of their wings, that butterflies and moths owe their tender shades, brilliant colors, and metallic lustres. A few butterflies are clear winged, with scarcely any scales, such as the *Ithomia* of Brazil, while the *Sesiidæ* represent the clearwings among the moths. Some orders of insects, such as the Hymenoptera, have four membranous wings like the Lepidoptera, but these are transparent and not clothed with scales. Others, such as the beetles, have the upper pair horny and useless for purposes of flight, the second pair being membranous but not scaly. The mandibles or jaws, found in most other four-winged insects except the Hemiptera or bugs, are replaced in the Lepidoptera by a long tubular proboscis or suctorial apparatus, used for exhausting the contents of honey-bearing flowers, or drawing in nutriment from less tasteful sources. In common with all other insects, the Lepidoptera have the body divided into three separate sections. The head, bearing the eyes, proboscis, and antennæ; the thorax, whence originate the legs below and the wings above; and lastly the abdomen, bearing along the sides the spiracles for breathing, and the generative organs at the apex. The abdomen is never attached by a narrow stalk or pedicle as in the Hymenoptera. So close may their general resemblance be to other insects, that, as is the case with the hornet clearwing moth, none but a naturalist could distinguish it from the common hornet. A general resemblance of body plan may coexist in individuals of two widely-separate orders, together with a habit of life and temperament, and likewise essential characteristics, wholly distinct and different.

Development The Lepidoptera also resemble the insects of most other orders in passing through several sharply defined phases before the last and perfect stage is attained. All first appear in the form of an egg laid by the mother on some food plant or tree. On hatching, the eggs give rise to a free-walking, feeding, sleeping, and breathing larva or caterpillar; thence, after successive changes of the skin, this passes into the quiescent, trance-like state, called the pupa or chrysalis stage; from this it at last emerges, at a suitable season of the year, as the fully-formed butterfly or moth. At the commencement of life the butterfly or moth is a thing of beauty even in the egg state. Butterflies' eggs, though falling into distinct groups of resemblance, on which even systems of classification have been based, are as various as they are beautiful. Globular, oval, flat, barrel-shaped, bottle-shaped, green, white, or brown, the egg is usually of a hue which renders it not easily visible on the leaf where it has been deposited. After a time the shell bursts, the tiny larva creeps forth, and commences feeding either on the egg shell or on the food lying in abundance near at hand. The larvæ are long, cylindrical, creeping, worm-like objects, with short legs, and a more or less hairy or quite naked body. The greater number feed upon the leaves of trees, shrubs, plants, and grasses; while many are internal feeders, burrowing deep into the decaying hearts of various trees. Others mine in the pith of thistles; while many more burrow at the roots of grass, or devour turnip roots, to the detriment of the crops. The larvæ of the mining moths (*Tineæ*) make sinuous channels between the upper and lower skin of various leaves. These in the perfect form are among the smallest and most lovely of all the Lepidoptera. Others, again, feed on clothing and

other woolen stuffs, gnawing ragged holes, and when the imago or perfect insect appears the mischief has been done. So voracious are larvæ that huge oak forests may be in a few days swept bare of almost every vestige of foliage.

Structure of Larva The body consists of a head bearing biting mandibles for nipping off the edges of leaves, or gnawing among decaying timber; a pair of small, short antennæ form appendages on either side; and just behind three simple eyes, or ocelli, on either side, very different from the large compound eyes of the perfect insect. Behind the head lie eleven segments or movable rings. Three of these, close behind the head, correspond to the thorax of the adult, and bear the three pairs of thoracic legs, short and horny, exactly corresponding to the three pair of legs of the butterfly or moth. The other segments bear the prolegs or claspers — varying in number from one to five pairs — used for clinging to leaves and other surfaces. In some of the moths the last pair are obsolete as legs, and are developed into a pair of horns, supposed to be for protective purposes, as, for instance, in the puss moth. A caterpillar may thus possess sixteen legs, though often there is not the full number.

A very curious form of larva is that producing the insects known as the geometers, so called because of the peculiar gait of the caterpillar, which measures out the surface over which it passes with a regular series of equal strides or loops. Their body is long, but since there are but four prolegs, they cannot crawl, but by bringing up the hinder-legs, advancing the head, and again bringing forward the tail, the caterpillar spans the space to be traversed by a series of looping strides. Hence the Americans call them "span worms." These larvæ, too, are remarkable for their resemblance — when the head is stretched outward — to a broken twig, a likeness which undoubtedly secures them from many dangerous foes. Many larvæ are protected by their similarity in color to the surrounding foliage, and it has been supposed that the pigment from the leaves which the caterpillar eats lends its characteristic hue to its devourer. From the moment of hatching until the final molt, when the caterpillar enters the pupa state, it undergoes a series of from eight to ten changes of the skin. These changes form crises in the lives of larvæ, which, at any rate in captivity, sometimes die during the process.

Pupa The stage immediately preceding that of the perfect form is usually called, when reference is made to the butterflies, the chrysalis state; but in the case of the moths, the pupa state, though there is no essential difference between the two. In this strange quiescent state the wings, legs, antennæ, and proboscis of the future insect can be seen fully formed and folded tightly within the outer covering. The only signs of vitality are given by wriggling movements of the segmented abdomen, when the pupa is irritated. The hard external covering is useful for resisting the attacks of predaceous insects, though of course not securing them immunity from mice, birds, or moles, which devour them with avidity. The chrysalis of a butterfly is usually angular and gilded. Some are suspended simply by the tail, others have a silken girdle round the middle to keep them fast, while some spin a very slight cocoon. The pupæ of the moths, on the other hand, are dull red, usually smooth mummy-like objects, to which likeness the word pupa or "puppet" doubtless refers. The greater part of these lie simply in the earth,

beneath moss or bark, wherever the larva has crawled to effect the change, without any additional covering. Others form a hard cocoon of the grains of mold, to which consistency is given by means of a gummy secretion furnished by the larva. Many form with this secretion a hard case, the outer side covered with chips of the surrounding bark, which, owing to their similarity to the surroundings, serve as a protection from observation. Others spin a silken egg-shaped cocoon, sometimes flocculent and broken, sometimes formed of yards and yards of silken thread, emitted from the mouth and passed over and under, across and round, until the cell is complete Among the more interesting of these cocoons is that of the emperor moth, which forms a short tubular exit closed against the entrance of earwigs and other insects by a circular series of fine bristles directed outward and converging to a point. The principle of contrivance is the same as that employed in the manufacture of lobster pots; but here the process is reversed, for in this case it admits of a ready egress but prevents any entrance. Moths whose pupa stage is passed within an external cocoon have a double task before them when the time is ripe for an emergence. The pupa itself — as does also the chrysalis of butterflies — splits at the dorsal suture above the thorax, and the moth emerges, ferreting a way through one end of the cocoon, which seems to be softened by moisture from within, and thus escapes. The imago or perfect insect, having now emerged, climbs to some point of vantage, where the wings, still very small, though completely formed, are allowed to hang downward, expand and harden in the air. After a few hours they are stiff and ready for use.

Enemies At no stage in their lives are lepidopterous insects free from the attacks of enemies. In the egg state they fall a prey to beetles and small birds, and as larvæ they are extremely liable to receive a deadly thrust with the ovipositor (or sting) of an ichneumon. As the ichneumon grubs grow at the expense of their host, scarcely a tissue in the whole body may remain, save those needful for the carrying out of life-supporting functions. And at last, when the grubs are themselves ready to pupate, and have no further need of their host, they finish up the rest and the larva dies — chiefly because there is nothing left to live. The enemies of the imago, whether butterflies or moths, are numerous. Birds, bats, dragon flies, etc., pursue and harass them whenever they happen to meet with them. The marvel is that any remain alive to lay eggs and perpetuate the species.

Mimicry In the struggle to escape detection and capture, all unconscious though it may be, arises the phenomenon previously alluded to, and known as protective mimicry. The kindred phenomenon of protective coloring, when the moth or butterfly merely resembles in hue the bark, leaf, or twig on which it rests; also protective resemblance, simply when insects take the form of objects, such as twigs, dead leaves, bits of decayed wood, flakes of white bird droppings; these are all well known. But protective mimicry means more, it implies the actual mimicking either the form, color, or habits of some other insect which is either too savage or unpleasant to make it a desirable object of food; as, for instance, the clearwing moths mimic gnats, bees, wasps, ichneumons, etc. Perhaps the most curious instance is that of the *Kallimas* or dead-leaf butterflies of Northern India, whose

upper sides are richly colored, while the under sides are dull brown mottled and veined with darker colors. So conspicuous a butterfly would not fail to fall a ready prey to foes. If it but settle for an instant, however, the sharpest eye will not detect them. The secret lies in the color and veining of the under side. The fly settles, clings to a twig, presses the tails of the under wings — now folded together against it —and nothing but an old withered leaf remains where but just now was a gaudy butterfly. A species of the genus *Heliconius*, an insect avoided by birds on account of its bitter flavor, is closely mimicked by another butterfly of the genus *Mechanitis*. Though very sweet flavored, it escapes unmolested among its less agreeable companions. The mimicry involved in the feigning of death by many species of moths is, of course, protective. It has even been asserted that a specimen of the magpie moth continued to feign death three hours after its head had been severed from the thorax.

Imago or Perfect Insect

If all the dangers noted have been passed through with impunity, in due time; at various seasons of the year, the perfect insects — butterfly, or moth, as the case may be — will emerge. These vary in size from twelve inches or more in the expanse of the upper wings to a quarter of an inch; — the latter being among the smallest moths, or Microlepidoptera. We have remarked that the body is divided into three distinct divisions, head, thorax, and abdomen; we must now shortly notice the various structures peculiar to each division. The first division of a lepidopterous body is

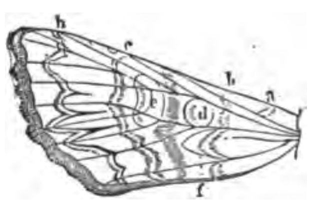
Head

itself divided into four main divisions. The occiput, next to the thorax; the epicranium, bearing the antennæ; and, in some moths, the ocelli or simple eyes; the clypeus, lying in front of the epicranium, just on the mouth parts, which latter themselves fall into at least five or six distinct structures; the proboscis, long, and capable of being rolled up beneath the labrum when a trest; the labrum, lying at the base of the proboscis, above; the maxillary palpi (absent or rudimentary in the butterflies); the labial palpi, and rudimentary mandibles, aborted in many cases, complete the mouth structures. It is in the structure of the mouth parts, perhaps, that the butterflies and moths differ most from other insects, and more especially from the fact that the mandibles of the insects have in the Lepidoptera become modified into a long, spirally curled, retractile proboscis, composed of three distinct hollow tubes, soldered to each other along their inner margins. Indeed, it has much the appearance of a double-barreled gun, with a third tube lying below beneath the suture of the upper and larger pair. But it is with this latter alone that nutrition is imbibed, and it is supposed that the other pair may furnish air in addition to that obtained through the spiracular orifices along the abdomen. The ocelli, or simple eyes, resembling those of the larvæ; the small eyes on the upper part of the head of bees and other Hymenoptera, as well as those of other Arthropods, such as we find to the number of from four to eight in the spiders, are not discoverable in the butterflies, but are present in the moths alone. The large compound eye, composed of numerous facets, is, however, present in both sections of the order, lying on either side of the epicranium, just below the point of insertion of the antennæ. Whether they see nature with these "as through a veil" or appreciate every detail as we do ourselves, is a matter of speculation, but

not easy of solution. The pair of thread-like, many-jointed organs, which take their origin from the side of the epicranium, just above and within the compound eyes, are among the butterflies, with the exception of the family *Hesperiidæ*, thread-like, and abruptly clubbed at the apex. In the latter family they are gradually thickened toward the end, which often terminates in a hook-like point. The moths, however, as their name Heterocera implies, furnish us with far greater variety in the form of the antennæ; quite apart from the fact that they differ in both sexes of the same species, thread-like, for instance, in the female, pectinate in the male sex, we find at least ten different forms of antennæ among members of this section: *Filiform*, or thread-like, gradually tapering to a point; *fusiform*, broadened from the base onward to the tip, which is again narrowed; *dilate*, narrow from the base to about one-third its length, then rather suddenly enlarged, and again narrowed at the tip; *ciliate*, clothed with the finest hairs; *setigerous*, each joint furnished with a bristle on either side; *setigerous* and *ciliate*, furnished with both fine hairs and paired bristles; *fasciculate*, each joint furnished with a group or tuft of short bristles, like a small brush; *dentate*, or toothed, each joint produced into a sharp tooth-like process at the side; *lamellate*, where each joint is produced at the margin into a small plate-like prominence; *serrate*, sawlike, each joint produced into a short sharp point at the side, giving the whole antennæ the appearance of a saw, the teeth are not so long as in the dentate antennæ; *pectinate*, each joint furnished with long plume-like hairs, or a pair of such on either side.

Thorax and Its Appendages

The second division of the body, like that of the Hymenoptera, is composed of three closely-united rings, each bearing beneath a pair of legs, while the posterior pair carry also on their upper or outer sides, each a pair of well-developed wings. The *prothorax* bears the fore-legs. The *mesothorax* the mid-legs and fore-wings. The *metathorax* the hind-legs and hind-legs. The legs are not used normally for walking, but are chiefly serviceable for clinging to objects while settling or at rest. They do not call for any special mention; and are not of great account for purposes of classification, except in the butterflies, where in the case of the males of the three families *Nymphalidæ*, *Erycinidæ*, and *Lycænidæ*, the fore-pair are much reduced in size, being in some cases almost rudimentary.



LEFT FORE-WING OF A NOCTUA MOTH.

a, *b*, *c*, *h*, indicate the normal position of the transverse bands. *a*. costal margin; *f*. inner margin; *d*. discoidal spot; *e*. reniform spot.

By far the most important structure in the eyes of the general naturalist, though not necessarily so in the opinion of the expert, are the beautiful membranous, scale-clad pinions. These give the distinctive characteristic to lepidopterous insects, and render them so fascinating to the lover of nature. Broad and ample on the whole among the butterflies, more narrowed as a rule among the moths — the hawk moths for instance — they are formed of the finest transparent membrane stretched out between the stiff rib-like nervures, or, more properly speaking, veins, which carry the nutritive fluids from the central system to all parts of the structure. The nerves, as custom will persist in terming them, in the butterflies take a bow-like or ellipsoidal sweep from

the base of the wing, forming what is called the *discoidal cell*, whence there branch off to the edges a series of horizontal, almost parallel, slightly divergent, nervures. On the position of these the identification of species is most securely based, though, in order to examine them, the insect must be spoiled as a specimen. In the moths, on the other hand, the *discoidal cell* is less conspicuous, though nervures branch off divergently from the base of the wing in a somewhat similar manner to those of the butterflies. One of the most remarkable features in the wings of the Heterocera, as distinguished from those of the Rhopalocera, is the existence of the frenulum and retinaculum, briefly referred to above as the hook-and-eye arrangement, with which the fore-wing is locked with the hind-wing. As already said, the scales are modified hairs, which take a more and more perfect scale-like form toward the centre of the wing. They lie in regularly-arranged rows, overlapping each other, attached by a short stalk to a small forea or pit in the membrane, to the number of many hundreds of thousands on each insect. Of different shapes and sizes they are themselves, owing to their exquisitely-sculptured surface, objects of extreme beauty. And it is to these alone that butterflies and moths owe their manifold tints, from the sombrest browns to the most resplendent metallic greens, golds, and purples.

Abdomen

The third division of the body is composed of a series of nine rings or segments, sometimes, as in the case of many of the moths, tufted along the dorsal line, and also at the extremity. The spiracles, through which the air passes to the tracheal system, lie along the sides of the abdomen, while the organs of reproduction are placed at the extremity in both sexes.

Extinct Forms

Butterflies and moths very rarely occur in the fossil state, owing no doubt to the delicacy of their integuments. Species of both, however, have been found in Tertiary deposits and some few in nodules of amber. The Tertiary beds of the Florissant lake basin of Colorado have furnished seven species of butterflies, a dozen of moths, and one caterpillar. Two specimens of hawk moths are known, in one of which is well preserved the spirally-coiled proboscis. Galleries of the leaf-mining *Tineina* have been preserved in leaves from the Chalk, while other Lepidoptera, a few pearl moths, owl moths, goat moths, silk spinners, burnets, and clearwings, together with a few species of *Vanessa* and blues, have also been recognized.

The Butterflies — Suborder **Rhopalocera**

As distinguished from the moths, the butterflies may be recognized as a general rule by their antennæ, which, as suggested by the name Rhopalocera, are slender and abruptly clubbed at the extremity. In some cases, however, in the family of the skippers, these organs are gradually enlarged toward the tip, which is itself often slightly hooked. Butterflies have not, in any case the hook-and-eye arrangement — the retinaculum and frenulum — by which the upper and under wings are in the moths interlocked along their inner margins. The fore-legs are not always well developed, and this is particularly noticeable in members of the male sex, forming a reliable characteristic in the broad subdivision of the Rhopalocera

into families. Butterflies are mostly diurnal in their habits, flying in the sunshine by day, although a few take wing only toward evening. Their eggs and larvæ differ considerably in many respects from those of the moths, while the chrysalis is seldom inclosed in even the finest network of silk, and in no case is wrapped in a distinct cocoon, nor even buried beneath the earth, very rarely even close to the surface. Usually the chrysalis is angular and blotched and speckled, with gold and silver ornamentation; sometimes it is suspended to a branch or twig by the tail, and sometimes while fastened by the tail also engirdled with a line of silk around the middle, thus tying in a position horizontal to the plane to which the larvæ has attached itself. These two characteristics also have been used for purposes of classification, and the suborder has been divided into Suspensi and Succincti on account of this difference in the attachment of the chrysalis.

Classification

The following broad subdivisions of butterflies may be made: Firstly, those which have four perfect legs only in both sexes, the fore-pair being rudimentary or undeveloped; while the chrysalis is suspended by the tail without any girdle. These include the family *Nymphalidæ*. Secondly, those having four perfect legs in the male, and six in the female, while the feet of the former have no claws at their extremity; the chrysalis being raised, resting on a leaf or suspended. The *Erycinidæ* represent this group. Thirdly, we have the family of the blues (*Lycænidæ*), in which there are six perfect legs in the female, and the chrysalis is suspended. The fourth group is that of the swallowtails (*Papilionidæ*), in which both sexes possess six perfect legs, while the chrysalis is attached by the tail and girdled by a silken thread. Lastly, the *Hesperiidæ* agree with the preceding as regards the legs, but the chrysalis is either attached by threads, or inclosed in a loose cocoon. As a rule, mountainous regions are those which abound most in butterflies, although there is a marked exception in the case of the valleys of tropical America.

The Fritillary Group

The family *Nymphalidæ* includes an extensive assemblage of butterflies, among which are the fritillaries, peacocks, painted ladies, tortoise-shells, and admirals. Here also come the leaf butterflies, purple emperors, white admirals, Camberwell beauty, and the large high-flying blue *Morphos*. We have also the subfamily *Satyrinæ*, which includes the ringlets, marbled whites, meadow browns, and graylings, besides many others too numerous to mention. First we may notice, as an example of the subfamily, *Danainæ*, the butterfly shown on the lower right-hand corner of the colored plate, which is known as *Euplæa harrisii*. In common with several other species, it belongs to a genus of large blue, and brown-winged tropical butterflies, in which the upper surface of the wings is usually spotted with white. At the top left-hand corner of the same plate is figured the male of the orange scallop wing (*Cethosia biblis*), which may be taken as a representative of the subfamily *Nymphalidæ*. It is an inhabitant of Northeastern India. Its black and spiny larvæ have the body banded with red and yellow, and the head surmounted with a pair of horn-like processes.

A better-known group are the fritillaries (*Argynnis*), which are mostly confined to the temperate districts of the Northern Hemisphere. In this genus, the British silver-washed fritillary (*A. paphia*) is among the finest representatives of a

large number of orange-red or fulvous insects whose hind-wings on the under side are spotted, spangled, or slashed with silver upon a dusted green ground. Not uncommon throughout England, it occurs in abundance in the glades of the New Forest, where the larva feeds on the dog violet or wild raspberry. The dark green fritillary (*A. aglaia*), a near relative, frequents the southern grassy downs along the margins of the cliffs, or sports in the fern-embroidered dells of the lake district valleys. The high brown fritillary (*A. adippe*), a rather smaller form whose hind-wings, as are those of the last-named species, are spotted with silver discs, while those of the silver-washed are slashed obliquely toward the lower angle. The Queen of Spain (*A. lathonia*), a much rarer insect, and the two elegant little pearl-bordered fritillaries (*A. euphrosyne* and *A. selene*) are also British. The greasy fritillary (*Melitæa aurinia*) brings us to another genus, the members of which closely resemble those of the former, but are as a rule smaller. So many figures of all the British species have been published, that detailed description is superfluous. The greasy fritillary inhabits low-lying marshy meadows in various localities in England, where the larvæ feed on the plantain. The heath fritillary (*M. athalia*) is a very similar though very local species; while the glanville (*M. cinxia*) is rare in Britain, where it is confined to the Isle of Wight. Many handsome species of this genus are found in all the more northern regions of the world, but undoubtedly the most numerous occur in the Southwestern United States. The magnificent fritillary (*A. childreni*), which measures nearly five inches from wing-tip to wing-tip, is indigenous to the Himalayas. Closely allied to the fritillaries is the map butterfly (*Araschnia levana*) of Central Europe. It presents two very distinct forms, one of which (*A. levana*) appears in the spring, the other (*A. prorsa*) later on in the summer, while an intermediate form (*A. porima*) is also recognized. The form known as the spring brood, figured on p. 3052, is fulvous red with scattered black spots, presenting also three white spots near the tip of the wing. The summer brood (Fig. 4) has black wings with a red marginal line, having besides a broad broken white bar across the wings and some white spots near the margin. The larvæ feed on the nettle in June and September. The insect, though common on the Continent, has not been taken in England. The curiously-shaped butterfly known as the common (*Polygonia c-album*), was formerly much more common in England than it is at present. The wings are rufous with black spots, and very strongly emarginate along the edges, and angular. The white c-shaped spots on either hind-wing beneath render it not easily mistaken for any other British species.

The handsome butterflies known as tortoiseshells (*Vanessa*) are among the most widely distributed of the family, though confined to the Northern Hemisphere. Most inhabit the more temperate regions of Europe, Asia, and America, although a few occur in India, Ceylon, the Malay Peninsula, and Mexico. The caterpillars feed on plants and trees, and are usually dark and spinous. The chrysalis, angular and distinguished by its brilliant lustre, is suspended by the tail, and forms a beautiful object. The large tortoiseshell (*V. polychloros*), so common in woods in England, is usually found settling upon the trunks of trees, in summer and autumn. The wings are rich fulvous red, blotched and margined with black, and having a narrow broken vein of blue just before the outer fringe. The larvæ

feed on the leaves of various trees, and the chrysalis is pale pink relieved with golden blotches. The small tortoiseshell (*V. urticæ*), whose jet-black spiny larva feeds on the nettle, is among the commonest British butterflies. The peacock butterfly (*V. io*), well known on account of the large eye-like blotches on the upper and under wings, is figured in all its stages in the accompanying illustration. The larvæ also feed upon the nettle; and the insect is found throughout Europe and Northern Asia as far as Japan, but not in Northern Africa. One of the handsomest, and at the same time of the rarest, of British butterflies, is the Camberwell beauty (*V. antiopa*). Its large angular wings are rich brown above, with a broad yellow border, inclosing on its inner margin a row of blue spots.

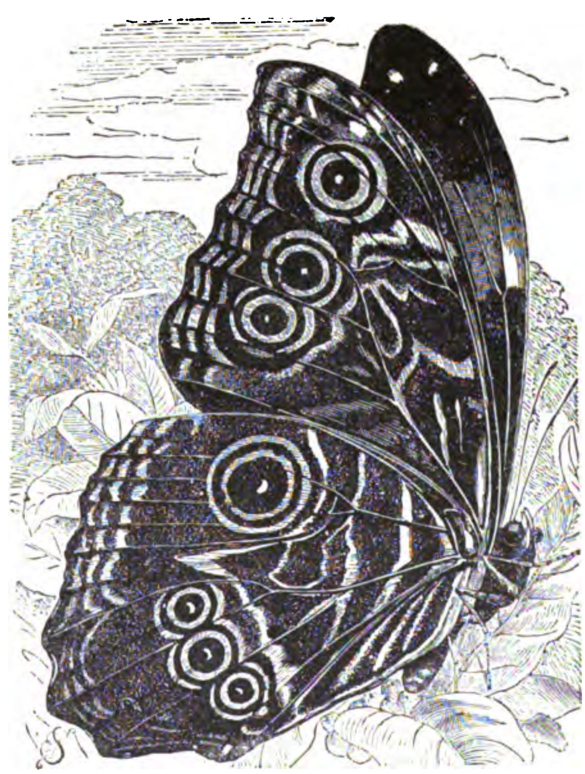
In the Tropics the place of the preceding genus is taken by *Junonia*, the members of which are not perhaps so richly colored as the tortoiseshells. They occur all over Eastern and Southern Asia, and are also found in North and South America, the Oriental countries, and Africa. The caterpillars are spinous, as are those of the two tortoiseshells. A figure of the beautiful, although dark-colored, Swinhoe's tortoiseshell (*J. swinhoei*), is given at the lower left-hand corner of the colored plate. As an example of the genus *Pyrameis*, we may take the red admiral (*P. atalanta*), which is a well-known and richly-colored British butterfly, appearing in the autumn in woods, and also in orchards where it feeds upon the juices of decaying apples. The large black wings with a scarlet band across the upper, and a margin of the same color around the lower, together with the group of pure white blotches toward the tip of the former, render it a very conspicuous insect. When, however, the wings are closed, the mottled black and brown render it almost invisible. The larvæ are black and spinous, and feed upon the common nettle; and the species is found all over Europe and North Africa, North and West Asia, and North and Central America. In many other regions its place is taken by some very closely-allied forms. In the painted lady (*P. cardui*), of which the caterpillars feed upon the thistle, the wings are orange red, black spotted,

GROUP OF BUTTERFLIES.

1. Peacock butterfly; 2. The same just emerged; 3. The caterpillar; 4. The chrysalis; 5. Meadow brown; 6. The caterpillar (natural size).

and black tipped, the latter area bearing a group of white spots. It is abundant in almost every country of the world, except the Arctic regions and South America. Nearly allied are the porcelains (*Cyrestis*), which measure from two to three inches across the wings, and are found in India, the Malay Archipelago, and a few in West Africa and Madagascar. The sooty-veined porcelain (*C. thyodamas*) represented on the colored plate, No. 3 from the lower right corner, is an inhabitant of Madagascar. Of the genus *Limenitis*, the large white admiral (*L. populi*) occurs in Central Europe, South Scandinavia, and Finland, but has not been met with in the British Islands or in Holland. It is nearly twice the size of the English white admiral (*L. camilla*), its wings being brown with a row of lunate orange marks near the hinder margin of the lower wings. The arrangement of the white bars on the upper wings is the same as that of the British form, but these are almost obliterated in the male sex. The under side is of a beautiful orange-yellow color, broken with white, and elsewhere suffused with various shades of purplish and bluish gray.

Closely allied to the admirals are the mango butterflies (*Euthalia*), which are almost entirely confined to India, the Malay Peninsula, and the adjacent islands. They measure from two to four inches across the wings, and the larvæ feed on the leaves of the mango. An illustration of the black mango butterfly (*Eu. lubentina*) will be found on the colored plate, No. 2 from the top right corner. The emperors (*Apatura*) are widely distributed over the world, except in Africa. Two species alone are found in Europe, and these are much more brilliant insects than the majority of the temperate species. The caterpillars are not hairy, but smooth, and bear a pair of horns on the head, as also does the chrysalis. In Britain the purple emperor (*A. iris*) is confined to the southern counties of England. Its strong purple shot, white-banded wings, three inches in expanse, carry it with a grand sweeping flight far above the highest oak trees, whence it descends, alas for imperial predilection, to a savory banquet of putrid flesh, set out in some suitable locality. The caterpillar feeds upon the sallow, and the perfect insect appears in July.

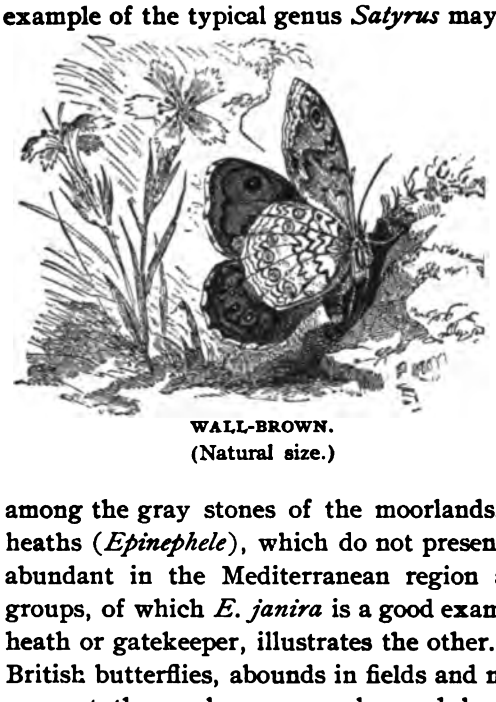


RESPLENDENT PTOLEMY.
(Natural size.)

Passing over many genera. containing some of the loveliest

foreign forms, we reach the subfamily *Morphinæ*, in which the caterpillars are remarkable for their bifurcate tail and notched or bifid head. The species of the typical genus are giant butterflies of almost every hue, the most conspicuous being of a dazzling metallic sky blue. Their long, satiny wings bear them aloft far out of the reach of the collector's net. In the preceding illustration is figured, from the under side, the resplendent ptolemy (*Morpho neoptolemus*). The upper side is rich black brown, with broad transverse blue bands, shot with delicate lilac across both wings. A pair of white spots are conspicuous on the tip of the fore-wing.

We have now to briefly notice a number of much less brightly-colored butterflies, many of which will be familiar to most readers, forming the subfamily *Satyrinæ*. They include the ringlets (*Erebia*), speckled woods (*Pararge*), marbled whites (*Melanargia*), meadow browns and heaths (*Epinephele* and *Cœnonympha*), wall-browns (*Satyrus*), graylings and common wood ringlet (*Hipparchia*), and many others. The caterpillars are mostly smooth, fusiform, and green, having two horns on the head and a bifurcate tail. They feed on grasses. These butterflies fly somewhat feebly over meadows, downs, highlands, and heath districts. As an example of the typical genus *Satyrus* may be taken the common British wall-brown (*S. megræa*). Here the wings are rufous brown, spotted, speckled, and streaked with black, having also a single eye-like spot on the upper wing at the tip, and three on each lower wing, near the margin. As a rarity, collectors prize a specimen in which the fore-wing spots are bipupilled, or having twin pale centres. Of the graylings (*Hipparchia*), the British *H. semele* is abundant in the heath and mountainous districts of England. Owing to its beautifully gray-mottled under side, it is absolutely invisible when settled upon rocks or among the gray stones of the moorlands. The nearly-allied meadow browns and heaths (*Epinephele*), which do not present a very great number of species, are most abundant in the Mediterranean region and Western Asia. They fall into two groups, of which *E. janira* is a good example of the one, while *E. tithonus*, the large heath or gatekeeper, illustrates the other. The former, which is the commonest of British butterflies, abounds in fields and meadows in the summer, ceasing to fly the moment the sunbeams are obscured by a passing cloud. Specimens with pale patches on the wings are valued by lovers of varieties. The upper figures on p. 3048 represent the adult and caterpillar.



WALL-BROWN.
(Natural size.)

Family *ERYCINIDÆ*

This small family, of which the characteristics are given on p. 3048, includes species chiefly found in the Tropics. *Erycina aulestes* of Brazil is peculiar in having

the mid-wings produced into a tail-like projection. As an example of the family we may take the Duke of Burgundy butterfly (*Nemeobius lucina*), an illustration of which is given in the colored plate, No. 2 from the lower right corner. Its brown, yellow-spangled wings once earned for it a place among the fritillaries. It is, however, the sole British representative of a family whose members are so abundant in Brazil.

The Blues and Coppers — Family *LYCÆNIDÆ*

This large family, represented by many small brightly-colored insects, include the blues, coppers, hairstreaks, and many others. Of the hairstreaks (*Thecla*) the

GROUP OF BRITISH BUTTERFLIES.

1. Large white admiral; 2. Golden-rod copper, female; 3. Male of same; 4. Small copper; 5. Azure or Clifden blue; 6. Silver-studded skipper; 7. Duke of Burgundy.

purple hairstreak (*T. quercus*) is a familiar example. This butterfly has the wings brown black, shot with purple, and abounds all through Europe wherever oak forests exist. It flits round the foliage, laying its eggs, and resting on the leaves, and is a

common British butterfly. The green hairstreak (*Th. rubi*) is a smaller species than the rest, with a bright green under side, and is not uncommon in some districts flying around bramble bushes in summer. In the allied genus *Polyommatus*, we mention the large copper (*P. dispar*) as one would speak of a departed friend, for, although formerly abundant in the fens of Cambridgeshire and other counties, it has

GROUP OF TROPICAL BUTTERFLIES.

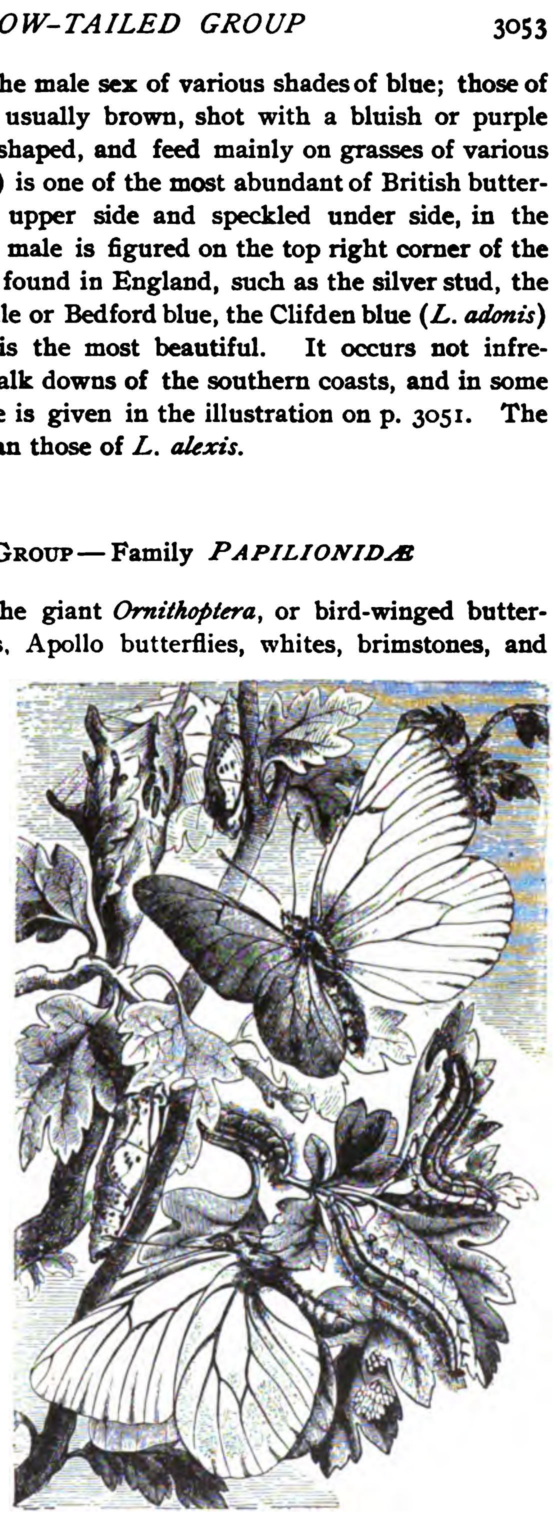
1. Scarce swallowtail, with larva and chrysalis; 2. Map butterfly, spring brood; 3. Larvæ; 4. Summer brood; 5. Chrysalis of same.

not been seen alive for over half a century in Britain. The small copper (*P. phlæas*) is, however, very abundant both in England and on the Continent. It is shown in No. 4 of the illustration on p. 3051. Of the golden-rod copper (*P. virgaureæ*) figures are given in Nos. 2 and 3 of the same illustration. This species is abundant on the Continent, though unknown in Britain. It flies in July and August, and the larva feeds on the golden-rod. The elegant little butterflies known as blues (*Lycæna*)

have the upper side of the wings in the male sex of various shades of blue; those of the female, on the other hand, being usually brown, shot with a bluish or purple tinge. The larvæ are wood louse shaped, and feed mainly on grasses of various kinds. The common blue (*L. alexis*) is one of the most abundant of British butterflies, whose white-fringed, pale blue upper side and speckled under side, in the male, are familiar to everyone. The male is figured on the top right corner of the colored plate. Of the many blues found in England, such as the silver stud, the chalk hill, the holly blue, and the little or Bedford blue, the Clifden blue (*L. adonis*) — the azure blue of many authors—is the most beautiful. It occurs not infrequently, though locally, upon the Chalk downs of the southern coasts, and in some other localities. A figure of the male is given in the illustration on p. 3051. The wings are of a much brighter blue than those of *L. alexis*.

The Swallow-tailed Group — Family *PAPILIONIDÆ*

This immense family includes the giant *Ornithoptera*, or bird-winged butterflies of the Tropics, the swallowtails, Apollo butterflies, whites, brimstones, and many others. As has been mentioned this family and the next are characterized by the possession of six perfect legs in both sexes. The chrysalids of the present family are suspended by the tail and girdled with a thread of silk. The largest of the butterflies (*Ornithoptera*) belonging to this family measure nearly a foot across the expanded wings. The typical members of the family are the swallowtails (*Papilioninæ*), which are large butterflies characterized generally by the presence of a long tail-like process to the hindwings. Occasionally, however, as in the female of *Papiliomerope*, these appendages are wanting. The two uppermost figures of the illustration on p. 3052 exhibit the scarce swallowtail (*P. podalirius*), which is a large, strong insect with triangular front wings, and a long tail at the lower angle of the hinder pair. In color the wings are pale yellow, with oblique transverse black bars. This splendid



BLACK-VEINED WHITE, WITH LARVA AND CHRYSALIDS.

butterfly, although common in Southern Europe, North Africa, West Asia, and Persia, is only very rarely taken in England. The larvæ feed on leaves of the sloe, apple, plum, and other orchard trees. The common swallowtail (*P. machaon*) was formerly very abundant in the fen districts of England, but since these have been drained it has become scarcer. The four wings are sulphur yellow, black at their base, with black veins, and hinder pair of the same color, with a band of blue toward the margin, and a red spot on the inner angle, close to where the tail springs. The larva feeds on the common carrot. This species has a very wide range, occurring in the Kashmir Himalayas. Of the royal swallowtail (*Tinopalpus imperialis*) from Sikhim, a figure is given in No. 2 from the top left-hand corner of the colored plate. The females are less brilliantly colored than the males, and have a pair of tails to each hind-wing.

The whites, clouded yellows, orange tips, brimstones, etc., represent the second subfamily (*Pierinæ*) of this assemblage, in which there are no tails to the hind-wings. One of the rarest British butterflies is the black-veined white (*Aporia cratægi*), shown in all stages of development in the illustration on the preceding page. Its caterpillar feeds on the leaves of the blackthorn and other bushes. Of a foreign representative of the group, the black-tailed sulphur (*Dercas verhuelli*), an illustration is given in the colored plate, No. 2 from the lower left corner. It is nearly allied to the common brimstone butterfly (*Rhodocera rhamni*), so abundant in spring in English lanes and hedgerows.

The Skippers — Family *HESPERIIDÆ*

This family differs from all the others in the broad, thick head; the hind-tibia (with some few exceptions) being armed with two pair of spurs. There are hundreds of species belonging to this interesting family, the majority being indigenous to South America. Many are distinguished by their powerful build, brilliant colors, and long-tailed hind-wings. The European species are all small, and more or less sombre colored, averaging about an inch across the wings. In the puss-tailed skipper (*Goniurus catillus*) of Brazil, the front wings are brown on the upper side, with five or six pale yellow spots; and the hind-wing also brown, and ending in long, broad flat tails, quite as long as the hind-wing itself. The antennæ are strongly hooked at their apex. *Telegonus alardus* from Venezuela has large wings, two inches across, brown, shot at their base with blue and green, but only very slight tail-like prominences on the hinder wings. To *Pamphila* and the following genera belong all the small, quick-flying butterflies, known as the skippers, properly so called. When at rest many of these insects raise the upper wings, leaving the lower ones horizontal, a habit not unknown among butterflies of other families. The Lulworth skipper (*P. actæon*) is a rare, or rather local, small brown skipper, confined in England to a few spots along the south coast. Among others are *P. silvanus*, the large skipper, *P. linea*, the small skipper, and *P. lineola*, the scarce small skipper lately added to the British list. The dingy skipper belongs to another genus (*Nisoniades*), as does the chequered skipper

(*Cyclopides*). The grizzled skipper (*Hesperia malvæ*) is a black or brown butterfly, with white spots on the upper side, common in England in summer. The silver-studded skipper (*H. comma*) is confined to some of the midland and southern counties of England, though abundant on the Continent. Figures of this butterfly will be found in the illustration on p. 3051, and on the colored plate, No. 3 from the top right corner.

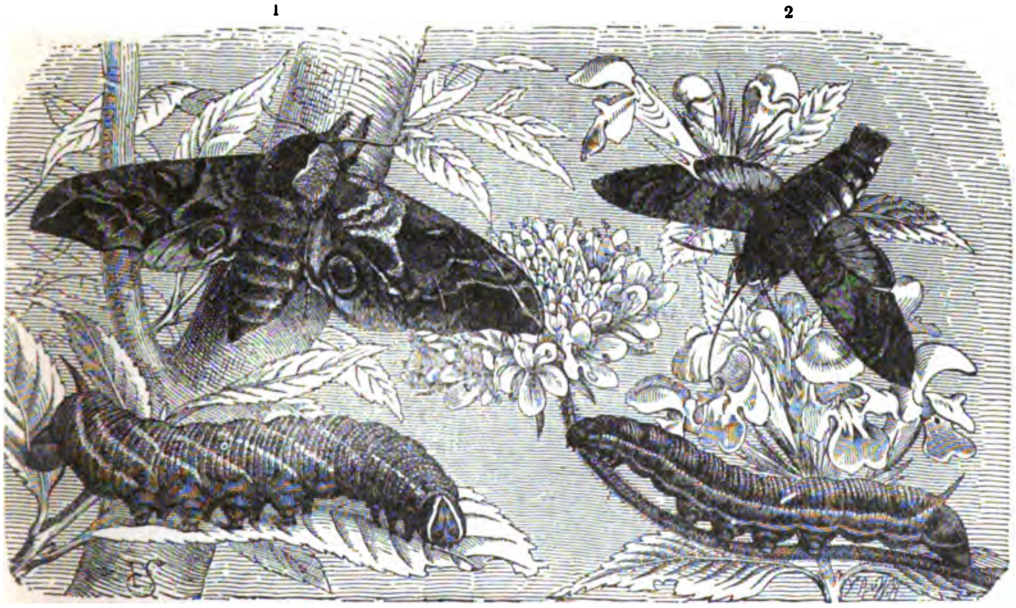
The Moths — Suborder Heterocera

Since limitations of space will only admit mention of a few of the genera and species of butterflies, we pass on to the moths, in which the antennæ are of many different forms, but never distinctly clubbed. Moths are vastly more numerous — both in genera and species — than butterflies; and, as already observed, are for the most part nocturnal insects. The other distinctive features having been already mentioned, we proceed to the first family of the group.

Emperor Moths — Family *SATURNIIDÆ*

The splendid moths included in this family are probably among the most beautiful, as they certainly are among the largest, of all known Lepidoptera,

1 2



HAWK MOTHS.
1. Eyed hawk moth and larva; 2. Humming bird hawk moth and larva. (Natural size.)

ranging in size from the atlas moth (*Attacus atlas*), which measures a foot at least in expanse of wing, down to the English emperor moth, of two or at most three inches in diameter. They do not, however, vary so very much in the comparative

beauty of their richly-colored ocellated wings. The larvæ, too, are not only of remarkable beauty, but have great commercial value; for it is from members of this family that China and Japan obtain vast quantities of a strong, though less expensive silk than that produced by the ordinary silkworm. The former are the oak silk moth of China (*Saturnia pernyi*), and its near relative *Antheræa yama-mai* of Japan. In all their stages these lovely insects are remarkable, differing widely in their general characteristics from the majority of moths. The larvæ, with their clear rich green velvet bodies, deeply cleft into separate, well-marked segments; their rounded warts, golden, rose colored, and sky blue, emitting long sinuous hairs, the latter, sometimes enlarged at the extremity, cannot fail to attract attention both for their unusual aspect and their beauty. When this stage is past, and the insect reposes in the large, leathery, sombre-brown cocoon, there is no lack of interest. The mouths of these cocoons, as noted at the commencement of the chapter, are fashioned for the better security of the slumbering pupa. No earwigs, beetles, or other prowling enemy can find its way into the cocoon to destroy the inmate, though the moth can readily emerge as soon as the outer shell of the inclosed pupa has been burst. For with a subtle ingenuity, no less wonderful because instinctive, the larva has carefully provided against these contingencies. It has arranged stiff, springy bristles round the orifice, each pointing outward, gathered in at their tips, so that unwelcome visitors cannot gain an entrance. But beyond all these interesting features, the perfect insects are themselves sufficient to enlist our admiration. The enormous, strong fore-wings with prominent anterior angles; the rich browns, purples, and grays in every shade and gradation; the large crescent-shaped or eye-like blotch on both fore- and hind-wing render the members of this family not easily to be mistaken for any other lepidopterous insects. True, the eye-like blotches recall to mind those of the peacock butterfly, but the stout, woolly bodies, the plumose antennæ, and the feathered legs of the emperor moths will show clearly enough that the resemblance is but superficial, and that there is no close relationship between them. The males fly swiftly, with a somewhat erratic flight in the broad daylight; and if the female, held captive in some receptacle, be placed in the open woods, many of the former sex will eagerly gather round the cage, and thus themselves fall victims to the net of the naturalist. There are many varieties included in the family *Saturniidæ*, though mention can be made of only a few. The common emperor moth (*Saturnia carpini*), one of the dwarfs of the family, is abundant in England, where, in the heather districts, the beautiful emerald larva, studded with rose or golden-yellow warts, may often be discovered wandering over some open sandy space or footpath. It is, however, at times scarcely distinguishable as it nestles among the heather stems, since the rosy warts on the back and sides assimilating closely with the pink heather blossoms secure it from observation. The moth itself — smaller and darker in the male sex — is of a deep purple brown. The fore-wings, richly variegated with grays, are bordered with a snow-white fringe, while the hind pair are orange margined with brown. Both fore- and hind-wings bear a black eye-like blotch, ringed with a narrow line of blue in the centre. The tough and dry empty cocoon may often be seen spun up among the heather stems. The common emperor is found all through Europe and in Northern and Western

Asia, while a much larger form, the peacock moth (*S. pyri*), is not uncommon in Southern Europe, and has been caught as far north as Paris. Passing on to the Chinese oak silk moth (*S. pernyi*), we find that its chief interest lies in the fact of the commercial value of its cocoon; a value which has not been fully recognized for more than thirty or forty years. The Abbé Perny, from whom it derives its scientific name, was the first to introduce it to the notice of European silk merchants, and from him we have a description of the method adopted by the Chinese in breeding and rearing the larvæ and winding off the silken treasure. Coppices of dwarf oak trees are cultivated, the earth is smoothed and cleansed with great care beneath the trees, while attendants are always at hand to shift the larvæ from one bush to another, or restore them to the foliage when they have fallen to the ground. The best of the cocoons from last year's cultivation are placed in a carefully-regulated temperature, and the moths are hatched off exactly at the season when the oak leaves are beginning to be ready for the larvæ. This will be about the month of April, when the females are laid in wicker trays where they may deposit their eggs. Soon, within ten days, the tiny larvæ creep forth and mount the oak twigs laid in the trays for their reception. Carried forth to the tender oak foliage, they quickly commence to feed, while the keepers are always on the watch to protect them from insect vermin, birds, etc., which, if permitted, would soon clear off the whole plantation. Forty-five days at the outside, and the larvæ are full fed; they then spin their cocoons, pass into the pupa state, and the winding off of the silken harvest begins. The largest cocoons are selected and set aside for the breeding of larvæ for another year. The rest are exposed to a high temperature which destroys the pupæ within. Boiling water — in which the earthly salts of buckwheat ashes cleaned for this purpose have been dissolved — renders the cocoon fit for being unwound. The silk is wound off in strands, — five, six, or eight in number, — a single strand from each cocoon, according to the strength of thread required. The silk thus prepared is much stronger than that from the silkworm moth, though it is neither so fine in texture nor so valuable. The Japanese oak silk moth (*S. yamamai*) is closely allied to the above, and the process of cultivation of the insect much the same.

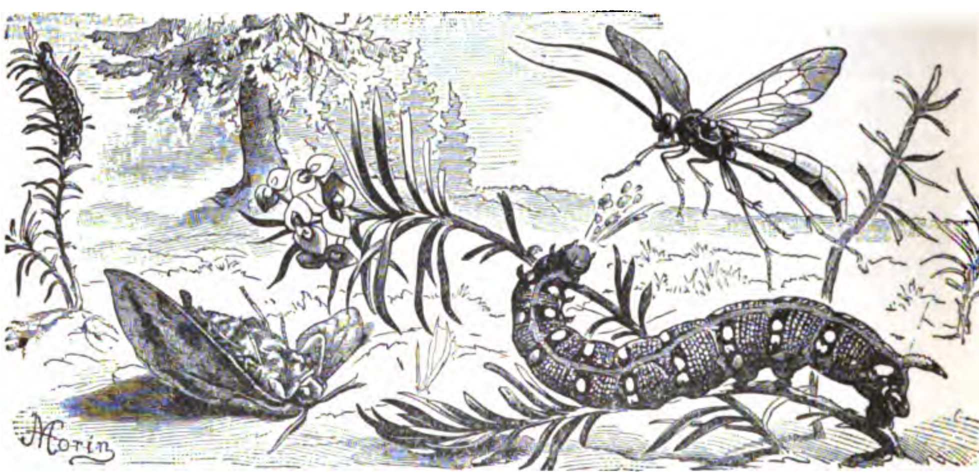
The Silk Spinners — Family *BOMBYCIDÆ*

The only species belonging to this family known in Europe is the one mentioned as the true silkworm moth (*Bombyx mori*). This insect has become acclimatized in many parts of Southern Europe, where, as in China, it is cultivated for its silken produce. The larva is itself not remarkable, save perhaps for its resemblance to the caterpillars of the hawk moths, with its smooth naked skin, and short erect tail. It is, however, by far the most valuable caterpillar yet discovered. Ages ago, from two to three thousand years before the Christian era,— if Chinese records be reliable,— this larva was well known in the far East, and already silk culture was a well-established element in the national industry. History relates how the eggs were first brought to Europe, in the reign of the Emperor Justinian,

by Persian monks, concealed in their hollow bamboo staves; and from these silk culture in Europe took its origin. It was, at any rate, carried on at Constantinople in A. D. 520. The Arabs introduced the industry into Spain, whence it spread in the twelfth century to Sicily, and thence to Italy and all the south of Europe. So far as England is concerned, both James I. and George I. endeavored to introduce the cultivation of the silkworm for commercial purposes, but without success. The actual mode of cultivation and preparation of the cocoon differs in no very essential feature from that of the oak silk moth, save that it is usually conducted under cover in well-ventilated rooms; the wicker trays of silkworms being arranged in rows one above the other on light bamboo racks.

The Hawk Moths—Family *Sphingidæ*

The large moths included in this family are either diurnal or subnocturnal in their habits, flying powerfully both in the daytime or just before nightfall. Among other characteristics, the antennæ are gradually thickened toward the tip, which terminates in a hook. The fore-wings are elongate, narrow, and usually pointed toward the apex; while the hind-wings are comparatively of small size. The larvæ are smooth, generally with a horn on the last segment of the abdomen. They make no cocoon, but the pupa lies in the earth, into which the larva burrows before



ADULT AND CATERPILLAR OF SPURGE HAWK MOTH, WITH ICHNEUMON FLY.

the transformation takes place. As is the case with almost all, they are protected by their coloring, which assimilates to that of the food plant. These fine insects are divided into several subfamilies and many genera.

As the type of the subfamily *Acherontinæ*, may be taken the well-known death's-head moth (*Acherontia atropos*), which is by far the largest of British moths. It is a very stout, bulky insect, with strong, broad wings; its thorax having on the upper side a pale mark, which bears some small resemblance to a human skull,

whence it derives its scientific and trivial names. The fore-wings are dark plum color, lined and spotted with the yellow; the hind-wings yellow, with two sinuous transverse bars of black; and the body dark plum color, with black transverse lines, and a yellow patch at the side of each segment. The most remarkable fact about the moth is that it is capable of producing an audible squeak. Whether this is pro-

OLEANDER HAWK MOTH, WITH LARVA AND PUPA.
(Natural size.)

duced, as was formerly supposed, by the friction of the palpi against the coiled proboscis, or by the sudden passage of air—previously drawn into a cavity in the stomach—through the œsophageal orifice and the proboscis, acting upon a cleft at the extremity of the latter, is not certain. If, as has been asserted, the squeak does not abate even on the decapitation of the moth, the air-passage theory suffers a shock, and evidently does not entirely account for the noise. The cleft at the end

of the proboscis would perform a somewhat similar function to that of the tongue in a penny trumpet, the reed in certain wind instruments, or the orifice in a whistle pipe. The handsome larva (green, with large, pale yellow, swollen anterior segments, and yellow, black-speckled oblique stripes across the sides), with its spinous tail, may be sometimes discovered on the jasmine and in potato fields. Not unfrequently, the large pupa tumbles from its friable earthen case, when the potato crop is dug. The moth flies strongly at night, feasting usually upon the sap oozing from the trees. It does not, however, hesitate to rob the hive of the honeybee, and apparently without molestation.

To the typical genus of the second subfamily *Smerinthinæ* belong several well-known British species, among which the eyed hawk moth (*Smerinthus ocellatus*) is figured on p. 3055 as an example. This moth is characterized by its angular, slightly-scalloped fore-wings and rose-colored hind-wings, each bearing an eye-like black spot, ringed with blue, near the inner angle. The larva is delicate green, its skin rough with minute warty points, with a series of oblique white stripes across the segments at the sides, and a short, sharp tail. It feeds on the willow and other trees, assimilating well in color with the leaves and their oblique veins; while the moth, hanging with half-closed wings, closely resembles a half-detached withered leaf. The insect is found throughout Europe and Northern Asia. One of the largest and most beautiful of the tribe is the oleander hawk moth (*S. nerii*). In this species the fore-wings are rich green, veined with white, having toward their base a triple, transverse rose-colored bar, whose posterior arm runs along the hind margin of the wing to the thorax. The hind-wings, thorax, and abdomen are green. The larva is green, with a pale band and numerous white speckles on the sides. The first three segments are suffused with yellow, and the third bears a large bilobate blue spot, outlined with black, on either side. The moth occurs throughout Europe, Africa, and Southern Asia; but neither larva nor perfect insect are often taken in England. The caterpillar feeds on the oleander and periwinkle in summer. Another beautiful, though small species, is the elephant hawk moth (*Chærocampa elpenor*), which typifies a third subfamily (*Chærocampinæ*). In this species the front wings are green, margined and veined with delicate rose color; the hind-wings black, with rose-colored borders; the thorax and abdomen of the same tint of green, with a central rose-colored band along the back, another at the sides; while the last two segments of the abdomen are rose colored. The larva is black, with three eye-like spots at the sides of segments three, four, and five, which are much enlarged, having also a rose-colored band along the sides. It feeds on fuchsia, bed straw, willow herb, etc., and is common in Europe and Northern and Western Asia in June. To the same subfamily belongs the members of the genus *Deilephila*, which have a world-wide distribution, although specially common in Southern Europe; among these, one of the commonest on the Continent being the spurge hawk moth (*D. euphorbiæ*). Although the adult is rare in England, the caterpillar has been observed in some numbers in Devonshire, feeding on the sea spurge. The fore-wings are gray and rose color in blended tints, with a large dull green spot at their base, and an oblique submarginal band of the same color, besides two smaller crescent-shaped spots toward the tip; the hind-wings delicate rose, with

black base, a deep crimson transverse bar, followed by a narrower black one a little beyond the middle; and the thorax and abdomen green, the latter with white sides. The caterpillar is black, speckled with yellow, having a dorsal rose-colored central line, a row of yellow spots along either side, and another below of red and yellow spots blended. It feeds on the sea spurge from July to September. In the figure on p. 3058 the larva is repelling the attack of an ichneumon, by ejecting noxious fluid into its face.

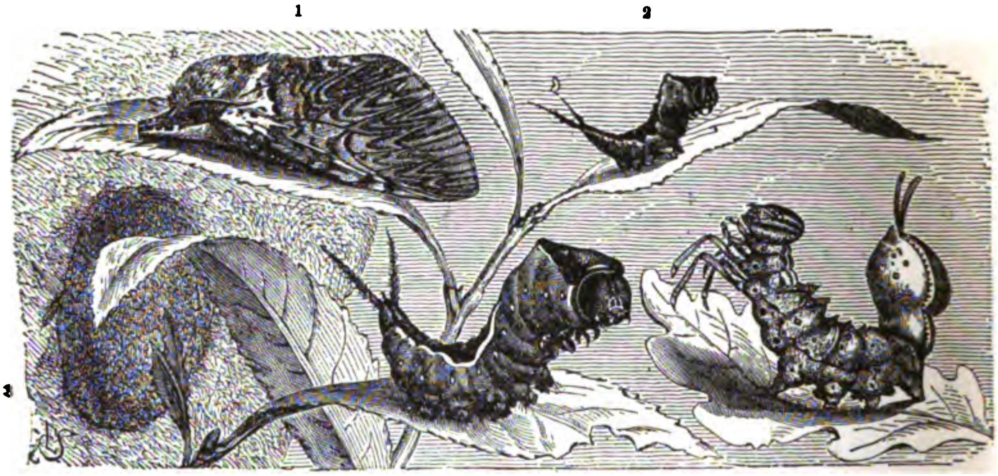
The pine hawk moth (*Sphinx pinastri*) belongs to the typical subfamily (*Sphingince*), and is a dull gray species, scarcely to be discerned as it rests on the similarly tinted bark of the pine trees on which the larva feeds. The moth lays her pale green eggs upon the pine needles, and in about a fortnight the larvæ emerge, and at once attack the needles. They have occurred in such abundance on the Continent as to ruin whole forests of pine trees, to the extent of many thousand acres. Although the moth is common throughout Europe, and several specimens have been taken in England, it is very doubtful whether a genuine British-bred specimen has ever occurred. The larva, which changes to a pupa beneath the earth, is green, with narrow longitudinal bands of red and white; these lines being naturally a great protection amid the longitudinal lights and shades of the pine needles. The species is figured on p. 3039.

Yet another subfamily (*Macroglossinæ*) is represented by the humming-bird hawk moth (*Macroglossa stellatarum*), shown in the figure on p. 3055. This small and swift species, which hovers with a darting, fluttering course over flower beds in the sunshine, is double brooded, and occurs almost all the year round. It has often been mistaken for a humming bird, whose flight it closely resembles, while travelers familiar with the latter mistake the long proboscis from which the moth derives its generic name for the slender bill of the humming bird. The fore-wings are dark black brown, and the hind-wings pale copper red. The sides of the abdomen are blotched with white, its extremity being thickly tufted. The larva is green or pinkish brown, with a pale stripe along the sides; and feeds on the lady's bed straw. The autumn brood of larvæ hibernate in the pupa state, the perfect insects emerging in the spring.

THE PROMINENTS — Family *NOTODONTIDÆ*

These moths — which are of moderate size, with stout, hairy bodies, long, ample wings, sometimes with a tooth-like tuft of scales on the inner margin — are very similar in general appearance to members of the family of owl moths (*Noctuidæ*). The antennæ are usually pectinate in the male, and simple in the female, but in some genera comb-like in both sexes. The larvæ, which in many species assume strange abnormal shapes and attitudes, are smooth and shiny, and without the last pair of claspers. In some cases the terminal segment bears a pair of tail-like processes, which can be raised or depressed, spread widely apart, or closed at pleasure. When full fed, the larva forms a tough cocoon, covered with chips of wood or other débris, in which it turns to a pupa. The perfect insects fly at night, and may sometimes

be found during the day resting on the trunks of trees, palings, or other suitably colored objects. A common British representative is the buff tip (*Phalera bucephala*), although it is more often met with in the larval state than adult. Yellow and black spotted, the young larvæ may be found together, feeding gregariously upon elms and other trees. The silver-gray wings, streaked and barred with rich browns, their tips painted with a patch of pale yellow, appear when closed, as the moth rests on the gray bark of a tree, exactly like a short, gray stick with the top beveled off on either side, and partially decayed. The puss moth (*Dicranura vinula*), is another common British species often found on poplar trees in the larval state, though the perfect insect is seldom met with. The latter has white fore-wings, tinged and marked with gray; the thorax being spotted with black. The compressed, globular, dull red egg is laid in the summer months on the leaves of the poplar or sallow, and the tiny caterpillars are at first quite black, but become greener as they grow older. When full grown, they assume, at rest, the characteristic position represented in



PUSS MOTH (1) WITH CATERPILLAR (2) in two stages of development, and (3) COCOON; (4) CATERPILLAR OF THE LOBSTER MOTH.

the accompanying illustration, whence they derive their name of puss moths, from some fancied resemblance to a cat. The bifurcate tail emits thin red filaments from the apex of each branch when the larva is irritated; the color being then bright green, with a red-brown or chocolate-pink patch margined with white behind the head, narrowed and then broadened at the sixth segment, and narrowing again to the tail. The cocoon is very tough, formed in some crevice of the bark gnawed into a convenient cup by the strong jaws of the larva. On the top are glued the chips thus obtained, and, with bits of lichen added, it almost defies detection among the surrounding knobs and rounded bits of bark. The species is common throughout Europe and Asia. The caterpillar of the lobster moth (*Stauropus fagi*) resembles nothing to be found in nature save those of the closely-allied species, as may be seen from the illustration. The moth is found, but not commonly, throughout Europe, and the larva feeds in July upon the oak, birch, and other trees. It is supposed that the extraordinary attitude, with head and tail erect, has proved bene-

ficial in warning off noxious enemies. Another type is represented by the figure-of-eight moth (*Diloba ceruleocephala*), in which the fore-wings are lead color, with a pair of white spots which sometimes bear a very close resemblance to figures of eight. The larva is blue green, with a central yellow stripe along the back, another below the spinners, while each segment bears a number of black warts, each with a black hair springing from the top. Illustrations of the moth and larva will be found on p. 3075. Of other forms, the dromedary prominent (*Notodonta dromedarius*), the zigzag (*N. ziczac*), the kitten moth (*Cerura bifida*), and the swallow prominent (*Pheosia dictea*), are among the more remarkable of the *Notodontidæ* indigenous to England. But we must leave this interesting group, and passing over the family *Cymatophoridæ*, including the peach blossom (*Thyatira batis*), frosted green (*Polyphloca ridens*), buff arches (*Habrosyne derasa*), and others, we reach

THE CLEARWINGS — Family *SESIIDÆ*.

These elegant insects — whose transparent wings, attenuated bodies banded with yellow and red, dilate and hooked antennæ, give them no small resemblance to members of the Hymenoptera — are diurnal in their habits, flying swiftly to and fro in the bright sunshine. The larvæ are what is called internal feeders, burrowing in the trunks of various trees, or in the pith of shrubs. The pupæ are armed with little hooks, which enable them to move up and down their tunneled galleries.

1 2

(1) HORNET CLEARWING, WITH LARVA AND PUPA; (2) GOAT MOTH, WITH LARVA AND PUPA.
(All natural size.)

There are many species even in England, one of the largest being the hornet clearwing; and so closely do this moth (*Trochilium apiforme*) and its near relative (*T. bembiciforme*) resemble the common hornet, or perhaps more nearly the female of one of the smaller wasps, that only a practiced naturalist would be able to tell the difference, and then only on a close examination. The wings are transparent, and the body is black, striped and spotted with yellow. The moth has a curious habit,

which increases the deception, and renders its likeness to some hostile wasp still more striking. If surprised sitting in the sunshine upon a poplar trunk, the abdomen will be arched upward, and the tail tapped against the bark with a veritable — to all appearances — stinging movement. The larva burrows in the wood of the poplar, and the pupa skin may be found half out of one of the galleries when the moth has emerged. The insect is common all through Europe and Northern and Western Asia.

Family *SYNTOMIDÆ*

The next family, the *Tiniageriidæ*, must be passed over, and a brief reference made to the moths of the family *Syntomidæ*, which introduces us to the well-known burnets. The *Syntomidæ* include small moths with broad, triangular, spotted wings, and body extended beyond the hind-wings. The members of this family are very similar in general appearance to the burnets, but differ in the absence of the ocelli. They are widely extended, and take the place of the burnets in the Tropics of the Eastern Hemisphere. Among them, the spangled white (*Syntomis phegea*) is a common moth in some localities on the continent of Europe, with blue-black wings spotted with white, as represented in the illustration on p. 3074. The larva is black, thickly clothed with hair, and feeds on the dandelion, while the perfeet insect flies, somewhat like the burnets, in the sunshine, and settles upon flower heads. It is not found in England, though extending through Europe to Northern and Western Asia.

We may also notice the handmaid moth (*Nadia ancilla*), a very rare species in England, but not uncommon in the woods of Southern and Central Europe in June and July. Its larva is black, with yellow lines on the back and sides, and it feeds on tree and rock lichens in spring.

The Burnets — Family *ZYGÆNIDÆ*

The burnets are for the most part small moths, with long, rather narrow fore-wings, and stout bodies extending beyond the hind-wings. Their usual color is black, green, or dark blue, spotted with red, white, or yellow. The hind-wings are gray, red, or similar in color to the fore-wings, with a narrow black margin; and the antennæ are somewhat abruptly narrowed toward the extremity. The burnets are local, though, from their gregarious habits, abundant where they occur. The larvæ are rather compressed, tapering at both ends; and the cocoon is long, spindle shaped, yellow or white, of fine shiny silk, and attached longitudinally to grass stems. Of the six-spotted burnet (*Zygæna filipendulæ*) the caterpillar feeds late in the autumn, and hibernates until the following spring. It is short, stout, slightly hairy, dull yellow, with two rows of black spots along the back, and feeds on grasses of various kinds. The moth flies heavily in broad daylight, and may often be seen, two or three together, hanging upon flower heads in chalk pits and on downs by the sea. Its fore-wings are black, with metallic-green lustre, having six bright red spots placed in three pairs; and the hind-wings are bright crimson,

GIANT SWIFT MOTH.

with a narrow black border. The species, which is abundant in certain parts of England, as well as on the Continent, is shown in various stages of development in the illustration on p. 3074.

The Case Weavers — Family *PSYCHIDÆ*

An interesting group of moths, although not noticeable either for size or coloration, is that of the case weavers. Their chief claim to notice is from the curious habits of the larvæ, which form from vegetable débris, twigs, chips, etc., a case in which they dwell, protruding merely the thoracic segments, with the three pairs of legs belonging to them. Some other moths, as for instance the genus *Coleophora*, also construct a tough case of a somewhat similar nature but manufactured entirely of silk. Among other insects the same habit of the larvæ is found among the caddice flies, which creep on river beds protected by a case of incrusted shells, pebbles, twigs, etc. In the moths of the present family the males alone possess well-developed wings, the females being wormlike, and often without antennæ, legs, or wings. The phenomenon known as parthenogenesis has been observed among members of this family. The moths are mostly dull brown insects, and the various species are better distinguished by a comparison of the larval cases than of the insects themselves. Of the many species embraced in this family, one only can be described, and this but briefly. This species (*Psyche unicolor*) is a dull brown little moth, common in Central and Eastern Europe, but not found in England. The larva of the male moth makes a larger and more conspicuous case, than does the grub which will produce the wingless female. The larvæ hibernate securely inclosed in their cases, which are spun on a tree trunk or other convenient object. In the spring the silken attachments are severed, and the larva continues to feed until the time of pupation has arrived, when it again spins up the mouth of the case to a tree or post, and changes within it to the pupa. The male then emerges as a perfect moth, but the female, which is devoid of eyes, ovipositor, or any appendages worthy of being styled antennæ or legs, remains in the larval case even after it has emerged from the pupa. The organs for the production of eggs are, however, complete, and parthenogenesis must, as in many other cases, be looked upon as exceptional.

PSYCHE MOTH.
a. Male; *b.* Female, larva in case; *c.* Female pupa; *d.* Female moth; *e.* Male, larva in case; *f.* Male pupa. (All of natural size.)

Family *COSSIDÆ*

The moths belonging to this family, like those of several others, do not possess any proboscis; the antennæ being pectinate in both sexes. The larvæ are smooth,

and feed sometimes for several years before pupating in the centre of tree trunks of various kinds; a cocoon being formed of chips of wood within which the pupa awaits its final development. The family is typified by the goat moth (*Cossus ligniperda*), in which the front wings are of a rich brown, streaked and mottled with darker tints, while the hind pair are dull brown. The larva — often known as the auger worm — is exceedingly destructive to forest trees, the holes which it bores in its ravages being often half an inch, and even more, across. Its odor recalls that of a goat, hence the name given to the moth. A large, long, flat, broad larva, flesh colored, with short hairs scattered over the body, it is seldom met with, though it sometimes may be found as it crosses a road or footpath when seeking for a suitable place in which to spin its cocoon. It lives for over three years in the larval state, and makes a very tough cocoon from wood chips, glued together with a gum which it secretes. It is a native of Europe and Western Asia, generally appearing in June and July. It is figured on p. 3063.

Allied Families

The next family (*Arbelidæ*) must be dismissed without further remark. The *Hepialidæ* include the insects known as ghost moths, one of which, the largest British species (*Hepialus lupulinus*) has the wings white above and brown below, so that when it flies in the dusk of the evening it appears and disappears in rapid sequence owing to the practical invisibility of the dull color of the under side, in sharp contrast to the vivid white of the upper side. A near ally of the ghost moth, likewise referable to the family *Hepialidæ*, is the splendid giant-swift moth (*Zelotypia stacyi*) of Australia, which has been selected for illustration in our colored plate, as being one of the finest of all moths. As the coloration and characteristics of this magnificent insect are sufficiently indicated in the illustration, it will only be necessary to give some account of its habits. Originally described from imperfect specimens found at the Manning river and in the neighborhood of Newcastle, this moth was subsequently obtained in some numbers by the miners of the latter district. Mr. A. S. Oliff writes that "as the insect is rarely found in the perfect, or imago condition, the larva has to be sought for and reared,— a matter of no little difficulty, as it lives, like those of the allied genus *Charagia*, in cylindrical burrows, which it makes in the interior of the stems or branches of trees, sometimes near the surface of the ground, and sometimes at a height of fifty or a hundred feet. By searching for these burrows, and rearing the larvæ, or pupæ, when found, a considerable number of specimens have been obtained by the miners; but I am informed that the supply is by no means equal to the demand."

The caterpillar is long, cylindrical, and fleshy. Above, its general color is pale yellow, with the divisions between the segments inclining to reddish brown. The first three segments are rather bright red; and the following segments, with the exception of the last two, are marked with three pale spots in the middle, and two on each side. The finely rugose head is black, as are the claws of the short legs. In the long and cylindrical pupa each of the abdominal segments beyond

the extremities of the wing covers is provided with a transverse serrated horny ridge near the front margin; the seventh to the tenth segments bearing similar but less prominent ridges; while the hinder extremity is armed with small sharp spines.

Usually the caterpillar makes its burrows in the wood of the gray gum tree; but there is some doubt as to whether it does not occasionally resort to another species of gum. Regarding the habits of the larva and pupa, Mr. Froggart writes that the former "changes into the chrysalis in December, after having eaten off the web in front of the bore, and placed a thick felty wad, or button, just inside the opening of the bore; but as soon as the chrysalis skin has become hard and firm, it pushes the wad away, and moves freely up and down the bore, which varies in depth from ten to twelve inches. It can move up and down the passage very rapidly, the curious file-like rings on the lower edge of the abdominal segments being evidently adapted to helping its locomotion. When nearly mature it has the habit, particularly in the afternoons, of resting in the bore, with the top of its head just level with the floor of the cross bore, and plainly visible from the outside. The moths appear early in March. It has been found that they never come out after three o'clock in the afternoon; and chrysalids under observation, if not out at that hour, can be safely left until the next day." The next family (*Callidulidæ*) must also be omitted; while the *Drepanulidæ* may be referred to as containing the British species *Cilix spinula*, and the common hooktip (*Drepana falcataria*), and allied forms. Of the *Thyrididæ* there is but one European genus (*Thyris*) and no British species of this; while the next family (the *Limacodidæ*) is not of sufficient importance to detain us.

Family *LASIOCAMPIDÆ*

The lappets, drinkers, and eggars, are well-known species included in this large family. These moths are large, for the most part, two inches to two and one-half across the expanded fore-wings, others being smaller, about one inch only in expanse of wing, with stout hairy bodies and strong wings. They fly rapidly in broad daylight or at night. The larvæ are clothed with soft hair, that on the sides being often directed downward in a tufted form. To the genus *Gastropacha* belong the lappet (*G. quercifolia*) and the oak eggar (*G. quercus*); the common drinker pertaining to another genus (*Odonestis*), with the specific name *potatoria*. As examples of the former genus we select for description the pine lappet and the procession moth, both abundant on the Continent, but not occurring in England. The larvæ of both these moths spin silken cocoons. Having the front wings gray, tinted with different shades of brown, the pine lappet (*Gastropacha pini*) is a large moth measuring about two and one-half inches across the wings. The larvæ are ashen gray, with a dorsal row of dark blotches, a lateral brown stripe, and a pair of blue transverse bands on the third and fourth segments. This handsome larva is often very destructive to the pine forests, where it feeds upon the needles of the trees, and sometimes appears in overwhelming numbers. In coping with the enormous quan-

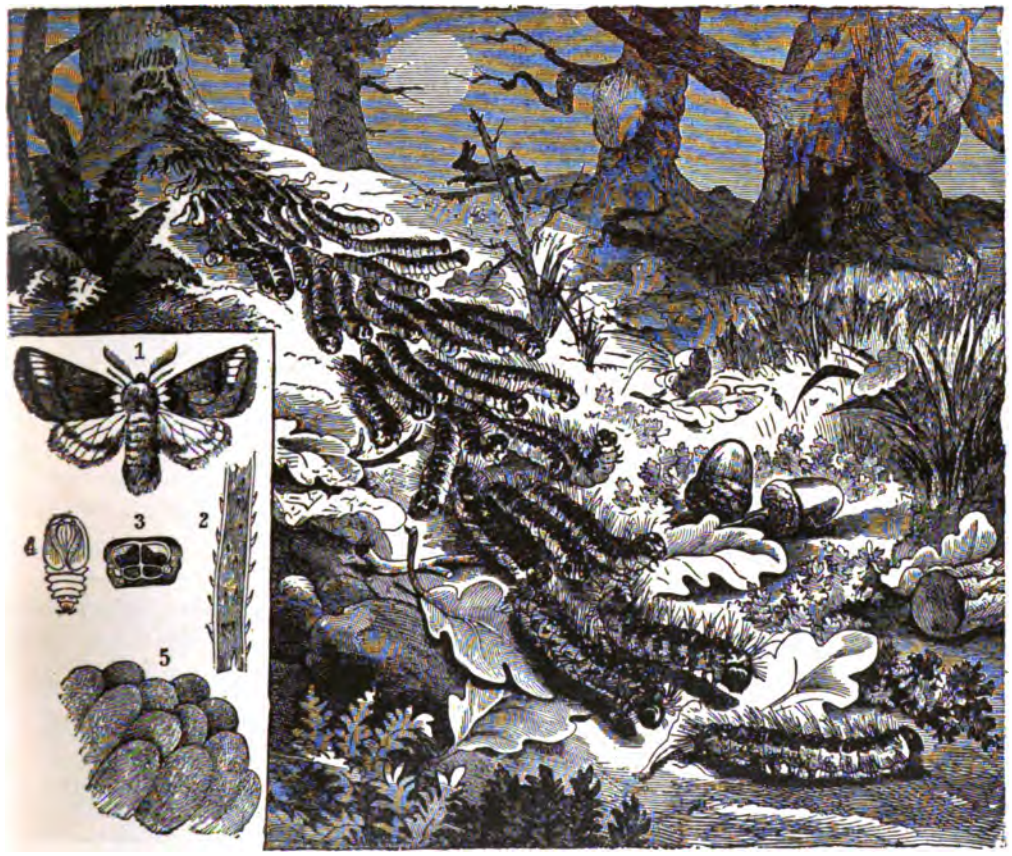
tity of caterpillars of this moth which devastate the district on these occasions, man is materially assisted by other creatures. Thus, a tree frog ascends and feeds upon the larvæ; ichneumons of different species sting, and thus destroy, thousands;

LIFE HISTORY OF PINE LAPPET MOTH.

a. Male; *b.* Female; *c.* Eggs; *d.* Larva; *e.* Cocoon; *f.* A beetle (*Calosoma*) attacking larva; *g.* Larva of *Calosoma*; *h.* An ichneumon laying its eggs in the pupa; *i.* Small parasites emerging from their cocoons on the remains of the larva which they have devoured.

an internal fungus establishes itself in the caterpillar, with the same result; and, lastly, a beetle and its larvæ, which are represented in the illustration, render no small assistance in clearing off the pest. The caterpillars are hatched in the autumn

and hibernate, remaining throughout the winter in the moss at the foot of the trees. In this state, coiled round in a spiral form, they may be frozen quite stiff, yet on the return of spring they regain vitality, and climb the trees in search of their usual provender. The red-brown cocoon is spun sometimes between the needles of the tree, as represented in the illustration, or else beneath some semidetached piece of bark. In the procession moth (*Gastropacha processionea*) the fore-wings are yellow gray, with a glossy sheen, and dark indistinct oblique transverse bars. The larvæ are hairy with a blue-black back, pale sides, and red or gray warts on each



PROCESSION MOTH (*Gastropacha processionea*). 1. Male; 2. Single hair of the larva; 3. Segment of larva; 4. The pupa; 5. The cocoons of several larvæ spun up together. (Nos. 2 and 3 enlarged.)
(The main illustration represents the migration of the larvæ in orderly procession.)

segment. At night the caterpillars march out to feed in a regular orderly procession, as represented in the illlustration. One, the leader, marches at the head, followed by two, three, and so on, forming a wedge-shaped column. They ascend the oak trees and return again in the same manner to their resting place. They also spin their cocoons together as in Fig. 5 of the illustration. The species is common throughout Central and Southern Europe in August and September. As our last representative of the family we take the lackey moth (*Clisiocampa neustria*), which is common in England and all through Europe and North and Western Asia

during July and August. The fore-wings are dull ochre brown, with two oblique transverse brown bars. The eggs are laid by the female in the late summer in a firmly attached ring round some small twigs as shown in the illustration. The larvæ hatch in the spring following, and are brown with blue, white, red, and yellow longitudinal stripes; all feed on the leaves of the pear and other fruit trees, and spin a long sulphurous yellow cocoon among the leaves.

LACKEY MOTH.
Perfect insect, eggs, larvæ, and cocoon.

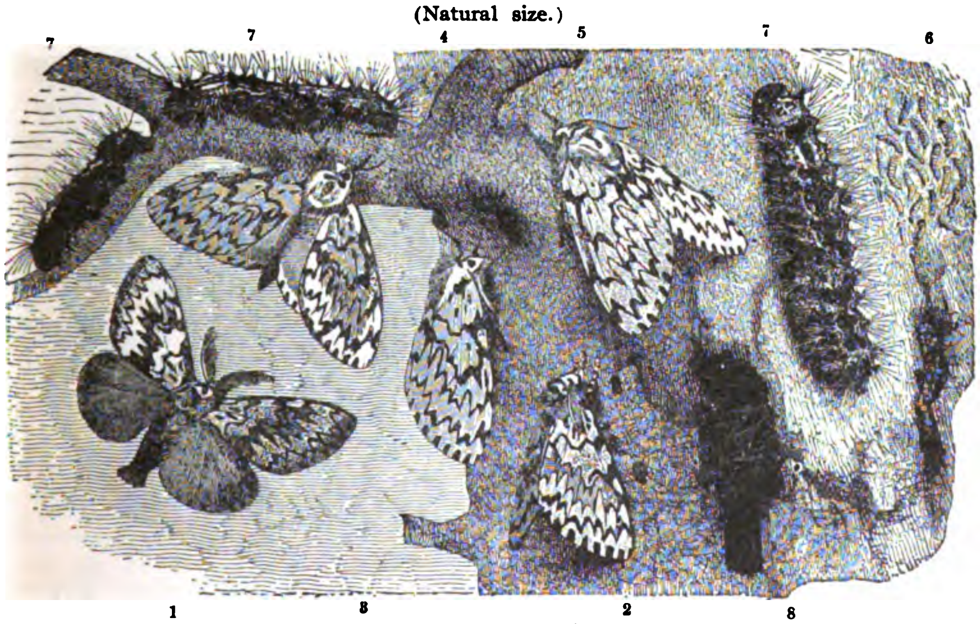
Family
LYMANTRIIDÆ

This group includes a number of moths in which the males have the antennæ strongly pectinated, while in the case of the genus *Orgyia* the female is wingless. None possess a proboscis. The larvæ are hairy, and clothed with long thick tufts, springing in some places from wart-like prominences. The hairs of the larvæ are woven into the cocoon, and if they come in contact with the skin cause great irritation. In this family are included some well-known British moths, such as the vaporer (*Orgyia antiqua*), the pale tussock (*Dasychira pudibunda*), the black arches (*Lymantria monacha*), the gold tail and brown tail, the satin moth, and many others. In the gypsy moth (*Ocneria dispar*) the wings of the male are smoky black, while those of the female are gray; the appearance of the two sexes being very different indeed. The larvæ feed on various trees, and though very rare in England are sometimes so abundant on the Continent as to prove very destructive to all kinds of trees and herbage; stripping even maize and millet fields, orchard, and vegetable produce.

HERMAPHRODITE GYPSY MOTH.

The cocoon is formed in a few folded leaves spun together with silk or in a crevice in the bark. The single figure represents an hermaphrodite specimen of this insect. Its wings, antennæ, and the dark half of the thorax and abdomen on the left side are of the coloring and form peculiar to the male, while those on the right resemble the form peculiar to the female. The illustration on p. 3071 illustrates the stages in the development of the black arches moth, which is not altogether abundant in England but much more commonly met

DEVELOPMENT OF GYPSY MOTH.
1. Male; 2. Female; 3. Pupa; 4. Larvæ in different stages.
(Natural size.)



BLACK ARCHES MOTH.
1 and 2. Males; 3, 4, and 5. Females; 6. Young larvæ; 7. Full grown larvæ; 8. Pupa.
(Natural size.)

with on the Continent. Indeed, so abundant is it at times that it causes great injury to forest trees. In Prussia, Lithuania, and Poland, the havoc has

PALE TUSSOCK MOTH, WITH ITS CATERPILLAR AND PUPA.
(Natural size.)

been particularly severe. In 1863 the moth appeared in countless thousands, driven up as a regular insect storm by the south wind. Within a few hours the moths spread over the whole country side, buildings were completely covered

BROWN-TAIL MOTH. 1. Male; 2. Female laying eggs; 3. Larvæ; 4. Pupa; 5. Antennæ of male; 6. Wing scales 7. GOLD-TAIL MOTH (*Porthesia auriflua*) larvæ; 8. Separate plumose hairs; 9. Segments of larvæ. (5, 6, 8, 9, enlarged.)

by them, and the very surf of the lake assumed a more snowy whiteness, due to the color of the hosts of moths drowned in the waters. The woods seemed as though visited by a violent snowstorm, so thickly were the insects massed in the

foliage. In 1852 whole forests were felled, in order if possible to be rid of the pest. The trunks were searched for eggs, and every tree trunk in an area of fourteen thousand acres was examined. Often an ounce of eggs would be taken from a single tree, and, at the computation of thirty thousand to the ounce, we get, at one hundred trees per acre, upward of thirty hundred million larvæ at work upon the trees in that area when the eggs hatched. Spotted woodpeckers, finches of all kinds, the larva of a longicorn beetle, *Clerus*, all assisted in the work of destruction. Yet, in spite of all this, it needed a hundred laborers with twenty foremen to carry out the destruction of the young larvæ hatched from eggs which were overlooked in a single acre of forest. The ground too, after the season was over, was white with the cocoons of countless thousands of *Ichneumonidæ*, so that millions of the larvæ can never, from the attacks of these alone, have reached maturity. The pale tussock moth (*Dasychira pudibunda*) derives its trivial name from the tufts or tussocks of hair so noticeable a feature in the hairy clothing of the larvæ. The fore-wings are gray with a smoky transverse bar. The larva is green with a transverse bar of velvet black between the segments from five to eight. Each of these segments bears a thick squarely truncated tuft of upright yellow hairs, and the last carries a long tail or brush of hair. The species is abundant in England and all Europe. In the brown-tail moth (*Porthesia chrysorrhœa*) the wings are snowy white, while the body is white with a brown tufted tail in the male, which in the female is much larger. The hairs of the tuft are deposited upon the eggs as a covering when laid by the female. The larva is short, thick, and black, with four rows of spiny tubercles along the sides. It is common in Great Britain and also on the Continent. Very similar to the last is the gold tail (*Porthesia auriflua*), but the front wings are dotted with three or more black spots, while the tuft at the extremity of the abdomen is formed of golden hairs instead of brown. The larva has rows of tubercles along the sides, whence issue numerous hair-like bristles. Each of the tubercles of the second row bears tufts of white hair. The third row is bright red. A bright vermilion double stripe runs along the back, while between the tenth and eleventh segments is a cup-like scarlet protuberance. The satin moth (*Porthesia salicis*) is another well-known member of the family, taking its name from the white satiny wings; the antennæ and thorax being also white, and the body black, clothed with white hairs. The larva feeds on the poplar, and is abundant in England and throughout Europe.

SATIN MOTH (*Porthesia salicis*), WITH LARVÆ AND PUPA.

An ichneumon is depositing its eggs in one of the larvæ, while another is just emerging from the pupa.

The Tiger Moths — Family *ARCTIIDÆ*

Two families, including many tropical species, come between the *Lymantriidæ* and the *Arctiidæ*, namely, the *Pterothysanidæ* and the *Hypsidæ*. The forms included under the name *Arctiidæ*, embracing a number of beautiful moths, such as the tigers, ermines, etc., are usually divided into four subfamilies, the *Arctiinæ*, represented by the tigers, properly so called, the *Lithosiinæ* including the footmen, the *Nolinæ*, and the *Nycteolinæ*. Of the first subfamily, the most familiar member is the common tiger moth (*Arctia caja*), which in summer comes freely to light. The fore-wings are rich chocolate brown with cream-colored markings; and the hind-wings crimson with black blotches. Two very beautiful varieties of this exceedingly variable moth are figured in the accompanying illustration. The larva is the well-known woolly bear, a large swiftly moving caterpillar, clothed with long bristling black hairs, red at their base, which spins a loose web, thickly covered with the hairs with which it is clothed, and turns to a naked pupa.

1. COMMON TIGER MOTH; 2 and 3. Varieties of same; 4. Larva of same; 5. SIX-SPOT BURNET; 6. Its larva; 7. THE SPANGLED WHITE.
(Natural size.)

The Owl Moths — Family *NOCTUIDÆ*

Passing over the family *Agaristidæ*, we reach the true night-flying moths, now included in the family *Noctuidæ*. This enormous group has been subdivided into no less than ten subfamilies. Of the first subfamily (*Trifeinæ*) the rustic shoulder

knot (*Hadena basilinea*) is a well-known example. In this moth the fore-wings are gray brown, with a central transverse darker band, and a distinct dark streak at the base of the wing. The larva is gray brown, with three white lines along the back. It feeds on various kinds of grass, and often on the ears of wheat devouring the corn grains. As its scientific name implies, the pine moth (*Trachea piniperda*) is in the larval state very destructive to pine trees in seasons favorable to a great increase in their number. When young, they spin together the needles of the pines, and often drop themselves by a thread to various points, whither they may feel inclined to descend. The pupa may be found in plenty among the moss which so often carpets the ground in pine woods. The moth itself is cinnamon red, with white blotches and spots. It is common in England and on the Continent. A figure of the moth and the larva is given on p. 3068. The merveil du jour (*Dipthera orion*), figured in the accompanying illustration, indicates another subfamily (*Acontinæ*). It has the fore-wings of a pale green, with longitudinal white stripes, and three

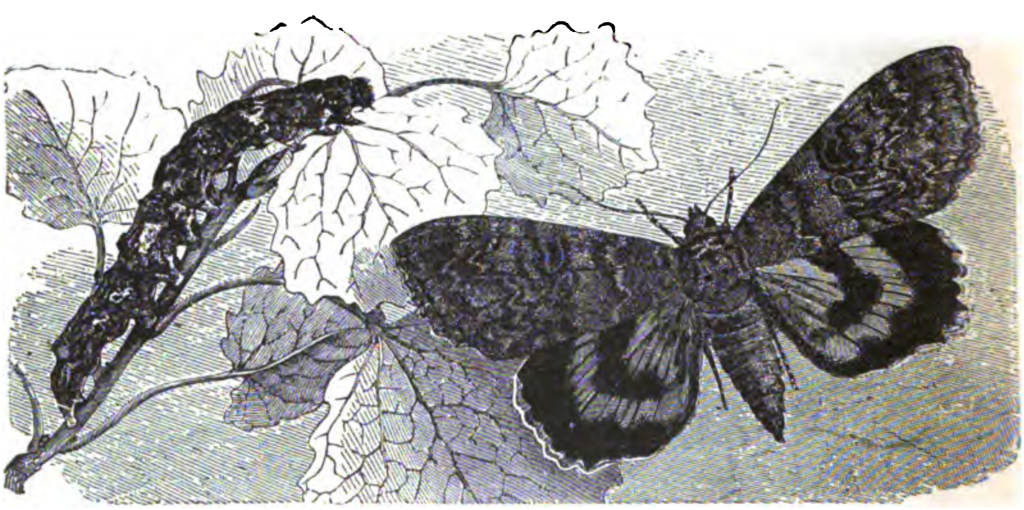
1. MERVEIL DU JOUR, WITH LARVA; 2. RUSTIC SHOULDER KNOT, WITH LARVA; 3. FIGURE-OF-EIGHT MOTH, WITH LARVA.

broken transverse black bars, the fringe being spotted with black and white. The egg is described as resembling a sea urchin, having twenty sinuous ribs. The larva is black, with large primrose yellow spots on the back of the third, fifth, and eighth segments. It feeds in September upon the oak and birch, and the pupa is inclosed in a cocoon of bark chips, or fragments of decayed wood. This insect is very rare in England, but common on the Continent. In the same group, the caterpillar of the white-spotted pinion (*Cosmia diffinis*), as well as that of the closely-allied *C. trapezina*, are remarkable for their habit of preying upon their fellow caterpillars if confined together, otherwise their food consists of the leaves of various trees. The moth of the species figured in the illustration is very beautiful, being of a satiny chestnut, suffused with reddish gray, and having two somewhat transverse slashes from the margin of the wing. Not uncommon in England, it is even more abundant on the Continent. The crimson underwings (*Catocala*), which indicate another subfamily (*Guadrifinæ*), and are known in the New Forest as the crimsons,

are rich chocolate brown of various hues, with deep crimson under wings, marked with a pair of transverse black bands. They come to sugar freely in July, and are common in some parts of England. The finest and rarest of these beautiful insects is the Clifden nonpareil (*Catocala fraxini*), very rare in England, but more abun-

1. WHITE-SPOTTED PINION MOTH, WITH LARVA; 2. PINE MOTH, WITH LARVA.
(Natural size.)

dant on the Continent. Scarcely less striking is the red underwing (*C. nupta*), in which the gray wings are mottled with darker shades, rendering it difficult to detect when resting on the gray bark of some forest tree. The hind-wings are pale crimson, with a central curving transverse black bar, and another broad black band



RED UNDERWING, WITH LARVA.
(Natural size.)

along the margin. The caterpillar is gray, with darker brown markings, bearing a pale yellow prominence on the ninth segment. It feeds on a species of willow, *Salix fragilis*, and the adult appears on the wing in August and September; being not uncommon in England, but found more abundantly on the Continent. In the

angle shades (*Brotolomia meticulosa*), which is one of the most beautiful, as it is one of the commonest of British moths, the larva is delicate green, smooth, and velvety, thickly speckled with minute white spots. It feeds on groundsel. The perfect insect, which appears on the wing in May and June, and a second brood in September, is common throughout Europe. In the prettily-marked species known as the feathered gothic (*Neuronia popularis*) the fore-wings are dark brown, with white nervures. The orbicular and vermiform spots are of the same color. The antennæ are pectinate in the males, and simple in the female; while the hind-wings are dull white, with darker margin. The larva is brown, streaked and spotted with black and rosy brown, with a pale stripe along the sides, and four others, more interrupted, along the back. It feeds on the various kinds of grasses in April and May, while the perfect insect appears on the wing in the early part of September. Figures of this European species are given below. The next form for notice is the so-called antler moth (*Charæas graminis*), which is probably one of the most destructive

1. THE FEATHERED GOTHIC, WITH LARVA; 2. ANGLE SHADES; 3. THE ANTLER MOTH.

species in Britain, when, under the influence of a favorable season, the larvæ appear in very great numbers. The larvæ feed upon the roots of grasses, and it is no uncommon thing for whole districts of pasture land to become brown and withered, owing to their attacks. The perfect insect appears on the wing in August and September. A figure of this moth is given above.

THE LOOPERS — Family *GEOMETRIDÆ*

The moths belonging to this group resemble in many respects the butterflies, having large, ample wings, a small head, and a narrow elongate body. The antennæ are not, however, clubbed; those of many of the males being pectinated. The palpi protrude only slightly, the proboscis is present in different degrees of development, while the head bears no ocelli on the top. When at rest, the majority of these moths carry their delicate wings slightly expanded, or closed over their bodies, like the roof of a house, sloping from the centre on either side. They are semi-nocturnal in their habits, appearing at dusk, and lying concealed during the day in bushes, trees, and herbage, whence they may be easily driven by beating the foliage. The larvæ differ very decidedly from those of the other families, several pairs of the prolegs being wanting, so that locomotion is possible only by alternately advancing

the front and hinder segments, the central portion of the body being thus raised in the form of a loop. The pupæ are sometimes, as in the butterflies, encircled with a silken thread, but the majority spin together a few leaves, and change within the receptacle thus formed, or burrow into the earth among dead leaves and moss. Of the first subfamily (*Boarmiinæ*) we select as a representative the handsome pepper moth (*Biston betularia*) which is one of the largest of the European geometers, and resembles members of the family *Bombycidæ* in the possession of a stout abdomen. The form of the larva, however, is quite distinct, and closely resembles that of a dead twig. Doubtless such a likeness saves it somewhat from the attacks of birds and ichneumon wasps. When fully extended, and clinging only by its hindmost claspers, the caterpillar assimilates so marvelously with the brown and olive tints of the boughs among which it takes up its station, that it is almost indistinguishable from its surroundings. Another handsome member of the same group is the mottled umber (*Hibernia defoliaria*), which appears very late in the season, long after the majority of the members of the order have completed the term of their existence. By night the male circles around the trunks of trees in search of his wingless partner. In the former sex the large wings are pale ochre in color, with a darker wavy transverse bar. The female, on the other hand, is variegated black and ochreous yellow, and bears no small resemblance to some species of spider. The larvæ feed on the buds of various trees, and descend into the earth to change into the pupa; the latter being dark mahogany, with a sharp spine at the tail. The species is not rare in England and on the Continent. The scarce umber (*H. aurantiaria*), which is figured in the same illustration, is less common than the last, but appears at the same season. Nearly allied is the winter moth (*Cheimatobia brumata*), which in mode of life is somewhat similar to the mottled umber, but, as indicated by its scientific name, flies still later in the year. The larva lives partially secluded among the leaves which it draws together with silk. When occurring in great numbers, these caterpillars do

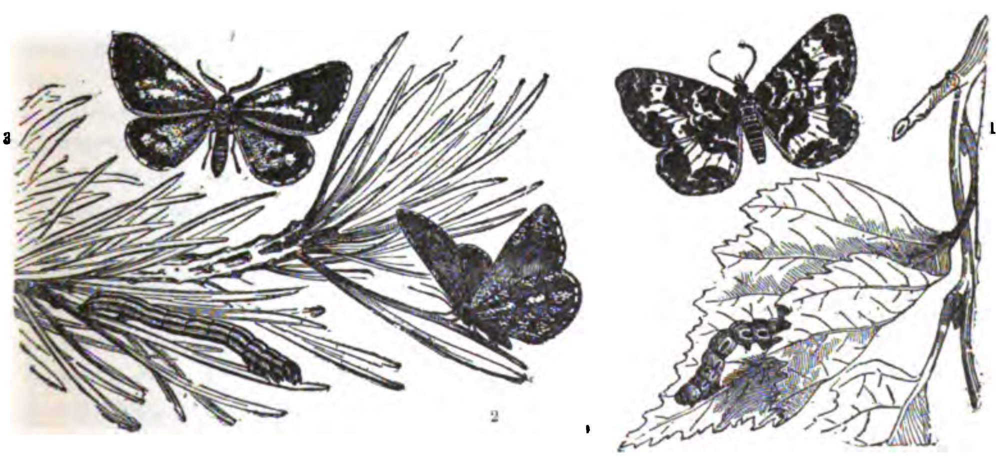
PEPPER MOTH, WITH LARVA AND PUPA.
(Natural size.)

serious damage to forest trees and orchards. The male is of a dusky gray color, with three darker bands across the upper wings; while the female is wingless. In

GROUP OF LOOPERS.

MOTTLED UMBER—1. Male; 2. Female; 3. Larva. SCARCE UMBER—4. Male; 5. Female. WINTER MOTH—6. Male; 7. Female; 8. Larva. (Natural size.)

order to prevent the females from ascending the trees and laying their eggs on the foliage, it is the custom in Sweden to ring the trunk with a narrow band of some



BORDERED WHITE—1. Male; 2. Female, with larva; 3. ARGENT-AND-SABLE, with larva.
(Natural size.)

sticky substance. The bordered white (*Bupalus piniarius*) is another well-known member of the group. In this species the males are very abundant, flying among

fir plantations in England and on the Continent. The females are no less common, but do not take wing so readily. The larva is pale green, with whitish stripes, and pale yellow spiracles, and feeds during the months of August and September on the spines of the Scotch fir. One of the most familiar of the British loopers is the magpie moth (*Abraxas grossulariata*), which at times makes its appearance in great numbers. The perfect insect is prettily mottled with white and black, and on this account is called in Germany the harlequin moth. Another species, the scarce or clouded magpie (*A. ulmata*), is more abundant in the Midland counties of England than the common magpie, though less so in the south. Of the common species the larva feeds on the gooseberry and black currant, doing considerable damage at times. It is one of the most strikingly marked of the geometric larvæ, and turns to a yellow-banded pupa within a slightly woven web. The little moth shown in the annexed illustration, and commonly known as the dark spinach (*Larentia chenopodiata*), may be taken to represent the subfamily *Larentiinæ*. Appearing in July and August, it is a common species on the Continent, and is epecially abundant in gardens and shrubberies, where it may be found resting either on the bark of trees or the walls of buildings. The caterpillar is grayish brown in color, and feeds on the goosefoot. The group to which this species belongs are often termed carpet moths. Of another genus, known as pugs (*Eupithecia*), the lime-speck moth (*Eu. signata*) may be mentioned. The ground color of the wings is milk white, with gray blotches and specks, and a broad red gray band on the margin. These moths fly commonly at night in England and on the Continent, while the larva, which is very variable in color — bluish green, yellow green, or pinkish

MAGPIE MOTH IN ALL STAGES OF DEVELOPMENT.

DARK SPINACH MOTH AND LARVA.
(Natural size.)

1. PURPLE-BARRED YELLOW; 2. LIME-SPECK.
(Natural size.)

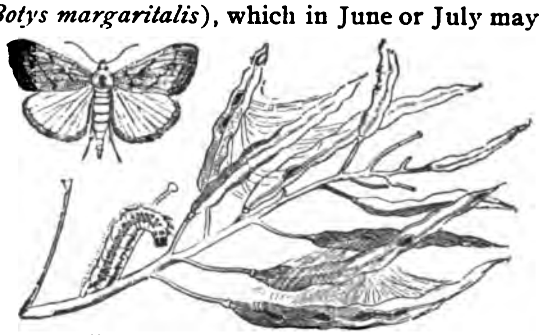
white — feeds in August and September on various annuals, such as goldenrod, ragwort, etc. Figures of the moth and larva are given on the opposite page. By no means a common species in England, although found occasionally in districts where birch trees abound, the argent-and-sable (*Melanippe hastata*) appears in May, flying actively round trees. The larva may be found later in the year among the birch foliage, in a receptacle formed of several leaves drawn together with silken threads. The pupal state is passed in the ground. Figures of this moth and its larva are given on p. 3079. The purple-barred yellow (*Lythria purpuraria*), figured on the opposite page, is a not uncommon species on commons, pasture lands, and stubble fields in England and the Continent. The ground color of the wings is pale olive yellow, the upper pair banded with two or three pale vinous-purple bars. The larva, which is brownish yellow with a pale longitudinal dorsal stripe, feeds on sorrel and docks.

SNOUT MOTHS — Family *HYPENIDÆ*

The snout moths (*Hypena*) are intermediate between the *Geometridæ* and *Pyralidæ*, bearing characteristics which ally them to both families and yet exclude them from either. The common snout (*H. proboscidalis*) is a pale brownish-yellow moth, transversely marked with rusty brown, and is abundant throughout England and the Continent from June to September. *H. obsitalis* has only once been taken in England.

SUBORDER **Microlepidoptera**

The whole of the remaining members of the order are of minute size, and are hence generally indicated by the above name, although it must be understood that many of them are closely allied to some of the foregoing. They are divided into a large number of families — with their subfamilies and genera — of which only a very few can be even mentioned here. Among these pearls (*Pyralidæ*) are represented by the mother-of-pearl moth (*Botys margaritalis*), which in June or July may be seen in Britain hovering over the fields in the dusk of the evening, where the female lays her eggs on the seed pods of the flax and other plants. When the caterpillar emerges it spins a few threads between the pods, and bores through their outer shell in order to feed upon the seeds. The moth itself is of a dull sulphur yellow, with two transverse rusty yellow bands, intersected by a rusty brown stripe running obliquely from the tip of the wing. It is common in June and July on the Continent. To the same family belongs the meal moth (*Asopia*



MOTHER-OF-PEARL MOTH, WITH LARVA.
(Natural size.)

farinalis), found in abundance in summer wherever corn, meal, or grains are stored in quantities. It rests on the rafters and walls in the daytime, flying at nightfall. The larva feeds on corn, meal, grain, bran, etc., and passes its life in concealment in a silken tube, of which the outer side is incrusted with particles of the food stuffs on which the larva feeds. The larval state lasts for nearly two years. A figure of this species is given on p. 3083.

OAK TORTRIX IN VARIOUS STAGES OF DEVELOPMENT.
(Natural size.)

The wax moth (*Galleria mellonella*) may be taken to illustrate another family — the *Tortricidæ*. This remarkable moth is double brooded, appearing on the wing in the springtime, and again in July and onwards. The larva feeds in the hives of honeybees, and, according to some, in the nests of wild bees as well. The wax, however — not the honey — forms its food stuff, and through the combs it eats long tunnels which it lines with silk as it goes. It does not seem particularly choice in the matter of diet, and has been successfully reared on heather, woolen stuffs, dry leaves, paper, etc. In the case of the wax eaters, the second brood nourishes itself upon the excrement of the first brood,

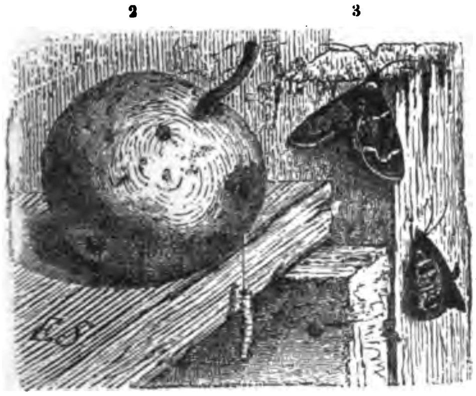
1. OAK GALL TORTRIX; 2. Pupa appearing from the resin gall; 3. *Glypta resinanæ*, ichneumon; 4. THE LARCH TORTRIX; 4a. Pupa; 5. Larva in a larch bud; 6. Pupa appearing from gall. (1 and 4a much enlarged.)

which seems to differ in no way from the original wax itself. The moth appears on the wing in May. An illustration of this insect, together with the larva, pupæ, and the waxen honeycomb on which it feeds, may be seen on p. 3084. Another

member of the same family is the oak tortrix (*Tortrix viridana*), figured on the opposite page. This beautiful little moth, bright green with shining gray hind-wings, may be found flying about in June in swarms in woods where oak trees abound. The larvæ which feed on the leaves, and roll themselves carefully within the folded leaves, are sometimes so numerous as to become a perfect pest. Acres and acres of oak plantation may be seen completely stripped of the foliage, while the green moths flutter about in countless thousands. The pupal state is passed in a folded leaf or in the chinks of the bark or other suitable crevice. The larch tortrix (*Retina buolinana*) is a bright, foxy red moth with habits very similar to those of the last-named species. The moth may be seen in July flying among the trees in young plantations, and laying its eggs among the buds at the tip of the shoots. The larvæ are hatched in the autumn and commence to gnaw the buds, giving rise to the exudation of resin. A figure of this moth, with its larva and pupa, will be found in the illustration on p. 3073. In the allied pine gall tortrix (*R. resinella*) the adult has dark fore-wings, streaked and mottled with transverse silvery bars and blotches. The larva feeds within the stem of the buds of the pine needles, their ravages causing a drop of resin to exude from the twig which grows larger as the activities of the internal burrower increase. If the drop of resin be examined a small passage at the base will be found passing into the pith of the pine twig, and here the larva may be found. This lump of sticky gum, which attains the size of a filbert, and in which the larva passes the pupal state, has been misnamed a gall; but a gall is not an exuding juice or gum—it is a distinct outgrowth of the cellular structure of the plant. The cut on p. 3082 gives illustrations of the moth, the resin drop, and the pupa. A figure is also given of the ichneumon fly, which seeks the larva with its long needle-like ovipositor; and from its eggs emerge the grubs which will in due course devour their nest. An especial interest attaches to the pea moth (*Grapholitha dorsana*), whose larva is the so-called maggot which attacks green peas. When full fed it seeks the earth, and constructs a cell in which to pass the pupal stage. These larvæ also are not averse to a provender of dry peas, to which it often causes considerable destruction. The moth appears on the wing in May. The well-known codling moth (*G. pomonella*) takes its name from the circumstance that the larva feeds within apple trees, eating, however, not so much the flesh as boring into the heart and feasting upon the pips. It is rosy red, paler beneath, with gray tubercles, each bearing a long bristle.

PEA MOTH AND LARVA.

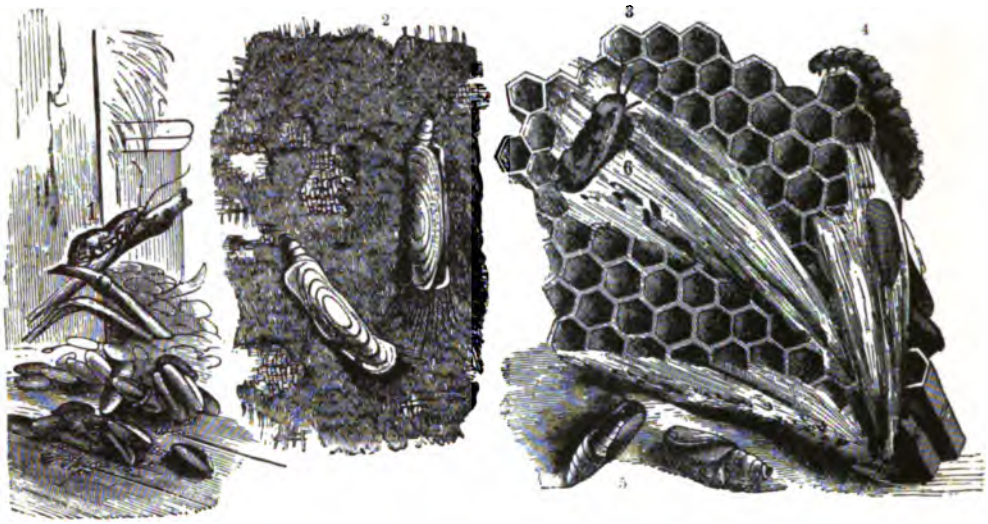
2 3



1

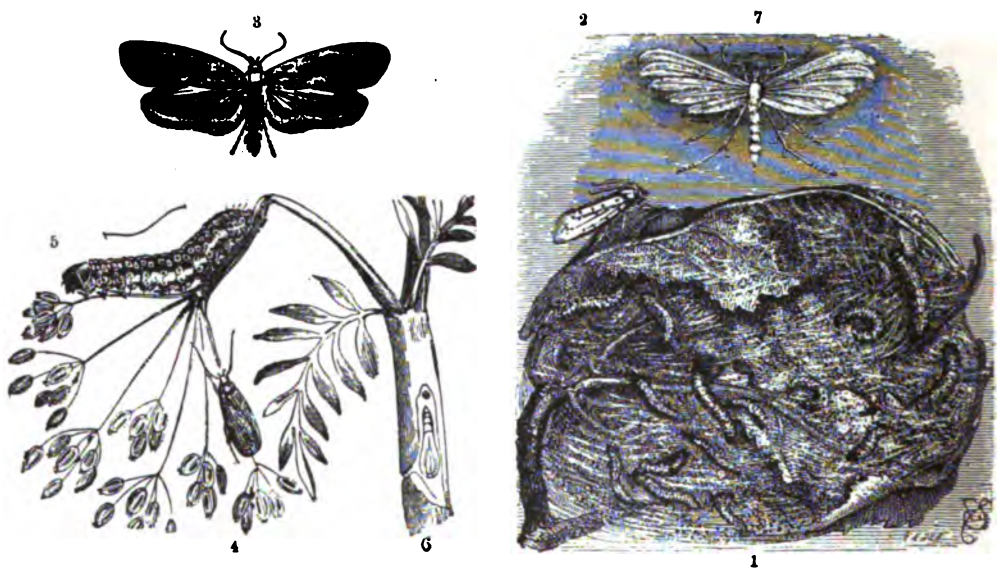
1. CODLING MOTH; 2. Its caterpillar; 3. MEAL MOTH.
(Natural size.)

This moth flies in June and conceals itself in the daytime in a crevice in the bark, with whose tints its gray mottled wings readily assimilate. The family of the clothes moths (*Tineidæ*) is typically represented by the lesser clothes moth



I. CORN MOTH, WITH LARVA; 2. LARVA OF CLOTHES MOTH; 3. HONEYCOMB, with 4. LARVA OF WAX MOTH; 5. PUPA; 6. WAX MOTH.

(*Tinea pellionella*), although it must be borne in mind that there is not one particular moth which destroys clothing, but that the larvæ of several species are



I. NEST, WITH LARVÆ of *Hyponomeuta malinella*. and 2, The moth; 3. *Depressaria nervosa* (enlarged); 4. The moth (natural size); 5. Larva (enlarged); 6. Pupa; 7. COMMON PLUME MOTH (*Pterophorus pentadactylus.*)

equally destructive. *T. pellionella* is one of the smaller of these, whose larvæ, of a silky yellow color, attack all kinds of clothing, as well as the upholstery of our

furniture. *T. tapetzella*, a larger species, attacks more exclusively furs, skin rugs, etc. A figure of the larvæ of one species will be found on p. 3084. In the allied corn moth (*T. granella*) the caterpillar is very destructive to corn in granaries, feeding indiscriminately upon various kinds of grain. The female lays one or two eggs on a single corn grain; and after the deposition of all the eggs, the bodies of the adults may be found in numbers in spider webs in places which they frequent. The presence of the caterpillar may be known by the "pass" or excrement on the grains. Several grains may be spun together, the larva feeding within the shelter of the receptacle thus formed. Figures of both moth and larva are given on the opposite page. Of certain allied species there are no English names, so that they must be mentioned by their scientific titles. Among these, *Depressaria nervosa*, figured in the illustration, appears on the wing from June to September, and has reddish-gray fore-wings mottled and streaked with black dots. The female lays her eggs upon cumin, and the larvæ soon after they emerge spin together the flower heads, feeding on the seeds and blossoms. When about to enter the pupal state, the larva bores its way into the centre of the food plant, gnaws out a suitable chamber, closes the entrance with a little door of silk, and remains safe from the attacks of insidious insect foes. In the same illustration is figured *Hyponomeuta malinella*, a familiar moth during June and July in English apple orchards. The satiny white fore-wings, with three longitudinal rows of black dots, render it a beautiful and conspicuous object as it rests on the apple tree by day, or flies to and fro beneath the trees as the evening draws on. The female lays her eggs in an elongated cluster on an apple twig, and the presence of the larvæ first becomes apparent owing to the silky gauze net with which the tiny larvæ spin the leaves together, enlarging their domicile as occasion requires. When full fed, they pupate also in the web, so that numbers of tiny pupæ nestle side by side where the larvæ were wont to feed. When alarmed, the caterpillars drop to the ground suspended by a thread, crawling actively away among the grass.

LARCH MINING MOTH.

Another family is typified by the genus *Coleophora*, which embraces about seventy species of small moths, characterized by their long narrow wings, margined with long delicate fringes, the first joint of the antennæ often bearing a tuft of hair. The larvæ live in little cases, in which they pass the winter, turning to the pupa in the spring. As an example of the genus, we figure the larch mining moth (*C. larcinella*), which is a dull colored moth, whose larvæ eat their way into the needles at the tip of young larch trees, the needles attacked, and indeed often the whole bunch, turning yellow and withering. The caterpillar is full fed toward the end of May, when it spins its little case fast to a larch needle, and turns to a pupa within. A few weeks later the moth emerges at

the hinder end of the case. Finally, we have the beautiful plume moths (*Pterophoridæ*), of which the common species (*Pterophorus pentadactylus*) is figured in the illustration on p. 3084. Throughout the family the larvæ are hairy, and when full fed suspend themselves by their anal claspers, turning to pupæ without any covering. The pupæ themselves are often hairy also, though many of them are quite smooth. The plume moths, as a family, may be recognized by their feathery wings, slender bodies, and long spinous legs.

CHAPTER IV

JOINTED ANIMALS — *continued*

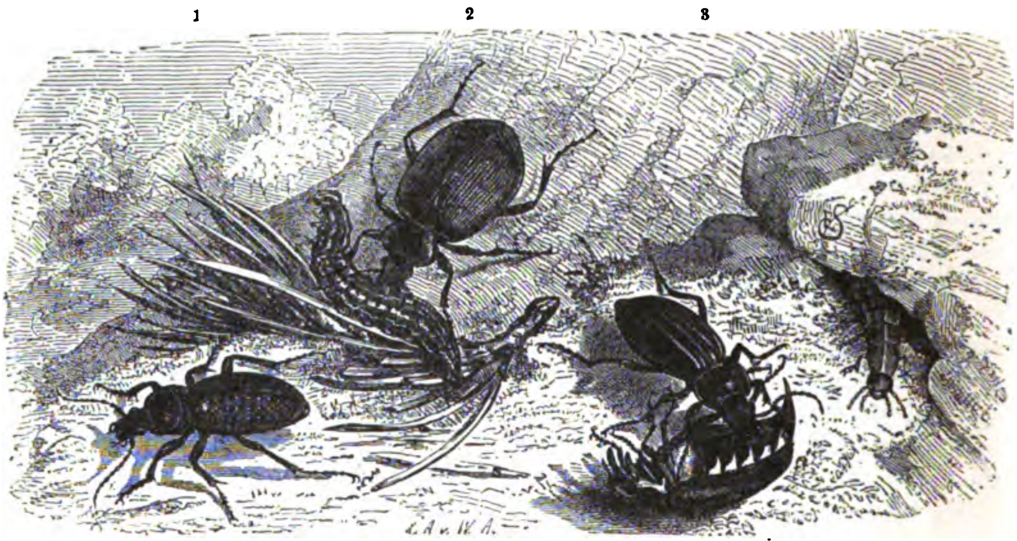
INSECTS — *continued*

THE BEETLES — Order COLEOPTERA

THE beetles are in general easily distinguished from all other insects, and though they seem almost endless in their variety, and comprise an immense number of distinct specific forms, constitute a very well defined order. The chief characteristics that serve to distinguish them are briefly as follows: They undergo a complete metamorphosis. Their mouth — which is fitted for taking in solid food — is furnished with biting jaws (mandibles), a pair of maxillæ with palpi, and an undivided, or very slightly divided lower lip (labium), which also bears palpi. The antennæ are extremely variable in form, but seldom possess more than eleven joints. The prothorax is usually large and is freely articulated with the following segment (mesothorax), over which it fits behind in such a manner as almost to completely cover it on the upper side. The fore-wings are converted into a pair of stiff horny structures called elytra, which, in a state of rest, usually meet by their edges in a straight line along the middle of the back, and serve to protect the hind-wings and the soft hind parts of the body. The hind-wings are in beetles the only true organs of flight; these are membranous and transparent, provided with few nervures, and when not in active use are generally folded transversely beneath the elytra. Many beetles are without hind-wings and are said to be apterous; but it is to be remembered that very few beetles, except in the larval state, are completely apterous in the sense of being without both hind-wings and elytra. In the wingless species the elytra are generally well developed, and frequently fastened together along the suture where they meet. The presence of elytra, though not exclusively peculiar to beetles, is still one of their most characteristic features, and affords in most cases a ready means of recognizing them. Elytra very similar to those of some Coleoptera are, however, met with among the earwigs; and the elytra of beetles do not invariably meet in a straight suture. Thus in the oil beetles (*Meloe*) one elytron folds partly over the other; while in certain other groups, the *Rhipiphoridæ* for example, the elytra are of such a form that they either do not meet at all, or only just touch at the base, and are sometimes so small and so little like the ordinary elytra of beetles that their true nature is not at first sight very apparent.

We have alluded to the great variety that is to be met with among beetles. No insects exhibit greater extremes of size; and we find on the one hand beetles so small that a pin's head is large in comparison, while on the other we get

those giants of their race, the elephant and goliath beetles, which are nearly as big as a man's fist, and the still larger titan from South America, which is sometimes quite half a foot long, and scarcely less broad in proportion. Even within the limits of a single species beetles are not always of a nearly uniform size; and it is not uncommon to find that in certain species some individuals may be very much larger than others, frequently two or three times as large, and occasionally even as much as five times. In their external form beetles also afford the most striking contrasts; and the differences of form are not confined to the general shape but extend to nearly all parts of the body. The head especially varies to a great extent both in its shape and in the direction which it takes. It is somewhat ring-like behind, when it fits more or less deeply into the cavity of the prothorax. The part between the eyes and the prothorax may be as wide as or even wider than the rest of the head, or may be abruptly or gradually narrowed behind to form a sort of neck. In



CARNIVOROUS BEETLES AND THEIR PREY.
1. *Carabus nemoralis;* 2. *Calosoma sycophanta;* 3. *Carabus auratus,* and larva. (All natural size.)

most beetles this part of the head is rather short, but its length varies; and there is one remarkable species from the Philippines which presents a most comical appearance owing to the extraordinary length of its neck. This species belongs to a group of leaf-rolling beetles, and doubtless finds its long neck extremely useful. The fore part of the head is most variable in shape, and though generally short is in some beetles quite out of all proportion in its length. In the weevils it is prolonged in the form of a rostrum or snout, which is sometimes much longer than all the rest of the body. What is called the "front" of the head frequently faces upward, being on the same plane, or nearly so with the occiput or posterior part of the upper surface. But in many beetles the fore part of the head is bent down, so that the front looks forward; and sometimes even to such an extent that the mouth is drawn back against the prothorax, and the front of the head looks downward. The lower or anterior part of the front of the head is called the clypeus, and to this — usually by

the intervention of a short flexible piece known as the epistome—the upper lip (labrum) is attached. Running along the middle of the under side of the head there is a piece, generally marked off by a line on each side, which in its posterior part is named the gula, and in front the submentum. The submentum—sometimes prolonged beyond the margin of the head in the form of a peduncle—gives attachment to the lower lip (labium), which consists of a basal piece of variable size and form called the mentum, and a terminal part, the ligula. The latter usually bears two lobes (the paraglossæ) at its extremity, while from its base, known as the hypoglottis, the labial palpi arise. Between the labrum and labium lie the mandibles and maxillæ. The mandibles are strong biting jaws, and are attached to the sides of the head by pivot-like joints, which permit only of lateral movements. They are often much larger in the males than in the females, and in the males of some forms such as the stag beetles, attain monstrous proportions. Each of the maxillæ consists typically of a stem, composed of two pieces—cardo and stipes—with a four-jointed palp attached to the outer and two lobes to the inner side of the free end of the stipes. Except in the larval state, beetles rarely possess those eyes with a single lens which are known as ocelli. The compound eyes, on the other hand, are generelly large and well developed, but vary considerably in form, and in the size and number of their facets. They are often simple in outline, sometimes slightly notched in front and reniform, or the notch may extend more deeply and divide the eye into two distinct lobes. Each eye may even be completely divided into two parts, more or less widely separated from one another; so that some beetles appear to have four eyes instead of two. This appearance is very strongly marked in certain water beetles, in which one part of each eye is on the upper, and the other on the under side of the head. The eyes of some beetles look coarse and granular, while in others they appear quite smooth and glassy looking, owing to the small size and slight convexity of their facets. Among the longicorn beetles, it is generally found that in the nocturnal species the eyes are coarser and more granular than in those species which fly during the day; so that the size of the facets seems to have some relation with the conditions of light depending on the habits of the insects. But this curious fact does not, so far as we know, apply to any other family of beetles. Exceptionally, also, it is found among beetles that the facets in the upper part of the eye are different in size to those on the lower part. The antennæ of beetles are scarcely less important in their functions than the eyes. They are in most cases sensitive to touch, and there is reason to believe that these organs are also the chief seat of the senses of smell and hearing. They appear under a variety of different forms, some of which, while subject to minor modification, are pretty constant throughout certain large groups of beetles, and thus account for the names, Clavicornia, Lamellicornia, etc., given these groups. As a rule, the antennæ, no matter what their length, are made up of eleven joints or segments; but this number may be increased, in some cases to thirty or forty (*Rhipicera*), and even to as many as fifty (in the Longicorn genus *Polyarthron*), or it may be reduced even to so low a number as two (in *Platyrhopalus*). When the joints are more or less cylindrical in form, the antennæ may be either filiform, if of nearly uniform thickness throughout, setaceous if they taper toward the extremity, or moniliform if

each of the joints is short and bead-like. The antennæ are said to be clavate when thickened at the extremity, in the form of a knob or club; lamellate when three or more of the terminal joints spread out in broad processes which lie flat upon one another; serrate, when the joints have on one side short angular processes like the teeth of a saw; pectinate or comb-like, when the processes are fairly long and stand out nearly at right angles; or flabellate, if the processes are proportionately very long. These are some of the chief types of antennæ met with in the Coleoptera; others of less frequent occurrence will be mentioned when we come to treat of the different families. The sense of smell is undoubtedly very acute in a great many beetles, as anyone acquainted with their habits could easily testify; and it is considered probable that certain minute pits scattered over the surface of the antennæ, or crowded together on special areas, are in some way connected with this sense. Though it is not so easy to prove that beetles can hear, it seems hardly open to doubt that in some cases at least they possess this faculty. Every one has heard of the deathwatch beetle (*Anobium*), which lives in old furniture and woodwork of houses, and makes a noise like the ticking of a watch. This little beetle produces the noise by hammering against the wood with its head, and apparently does so for the purpose of attracting its mate, who replies by making a similar tapping sound. It is easy by imitating their sounds to get the beetles to answer back; so that here at least there is some evidence that these insects are endowed with the faculty of hearing. Many other beetles are able to make sounds, which though not nearly so intense as the chirping of the crickets and grasshoppers, and not usually confined to one sex, are produced somewhat after the same manner by the friction of one part of the body over another. In beetles the sound sometimes arises from the rubbing of the hind-legs against the edge of the elytra, but in most cases it results from the rubbing of an edge over an adjacent area which is crossed like a file by a number of fine parallel ridges. This stridulating area is in some beetles placed on the upper side of the back part of the head, or on the gular surface underneath, so that when the head moves in its socket the upper or lower edge of the prothorax, as the case may be, scrapes along the file and thus gives rise to the sound. The prothorax of beetles is, as we have already stated, freely articulated with the mesothorax. Its dorsal arch or pronotum ordinarily covers over the whole of the mesonotum, with the exception of the small piece known as the scutellum; but when the prothorax is bent down, a considerable part of the mesonotum in front of the scutellum comes into view. It is on this part that the stridulating area of most of the longicorns and of some phytophagous beetles (*Megalopinæ*) is situated. These insects make a sort of squeaking noise — which is sometimes fairly loud — by rapidly bending the prothorax up and down, and so causing its hind edge to move backward and forward over the ribbed surface of the mesonotum. In other beetles the stridulating area may be either on the upper surface of one of the hinder segments of the abdomen, or on the sides of one of the anterior segments; the sound being produced in the one case by the friction of the area against the edge of the elytra, in the other by that of the posterior thighs against the sides of the abdomen.

Beetles are among the most active of insects when on the ground, and, in accordance with their running powers, we find that their legs, though generally

slender, are strong and well developed. But in certain groups, where the habits and environment of the insects require it, the legs are adapted to various other purposes. Beetles that jump usually owe their leaping powers to the greatly thickened femora and straight and relatively long tibiæ of the hind-legs. It would, however, be a mistake to suppose that when a beetle has thickened and strongly developed hind-legs it must consequently be able to jump. Some burrowing species, and others that are not very active in their movements, have very thick hind-legs; though, as a rule, it is the front pair of legs which is thickened and otherwise modified to serve as digging organs in those beetles that burrow underground. In aquatic beetles the swimming legs are disposed like oars, and have all their parts broad and flat, while their breadth is further increased by rows of bristles. Either the hind-legs only, which is the rule, or the middle pair also, as in the whirligig beetles (*Gyrinidæ*), may be thus transformed into swimming organs. The coxæ or basal joints of the legs vary much in shape and in the mode in which they are inserted in their sockets on the under side of the thorax. Those of each pair are sometimes close together, sometimes widely separated from another; while a longer or shorter distance may intervene between the coxæ of the different pairs of legs, and especially between those of the two hinder pairs. Considerable importance attaches to the number of joints in the tarsi or feet. In classifying beetles this number is one of the first things to be noticed. If a beetle has five joints in each of its tarsi, it is placed in that section of the order which is known as the Pentamera; if it appears to have only four joints in each foot, it belongs to the Tetramera; and if but three, to the Trimera. When there are five joints in each of the four anterior feet, and only four in the hind-feet, the beetle may be regarded as one of the Heteromera. To these general rules there are a few exceptions which need not be discussed here; but we must point out that although in the Tetramera the tarsi appear to be four jointed, and in the Trimera three jointed, they are really composed of five joints and four respectively. The fourth joint in the one case, and the third in the other, are, however, usually so small as not to be noticed except upon very close examination. The abdomen is never stalked in beetles, but attached to the thorax by a broad base, which is applied against the posterior coxæ; exceptionally, however, as in certain mimicking species, its base may be more or less narrowed. It is generally somewhat flattened in shape; and on the upper side eight segments are usually distinguishable, which, so far as protected by the elytra, have a soft and but slightly horny integument. Five or six segments are generally visible on the ventral side, but in certain cases the number may be reduced. The terminal segments are usually retracted within the abdomen, and completely hidden from view, but in the females of many species they can be exserted in the form of a tubular ovipositor, which enables the insect to lay its eggs deep in the crevices of bark.

Although beetles do not always exhibit differences in external form by which the sexes may be distinguished, such differences frequently exist, and are sometimes of the most pronounced character. As a rule, the male is more slenderly built than the female, and has longer and more fully-developed antennæ; his eyes also are often larger, and in the length and shape of the legs, and in the width and

structure of the tarsi, differences in the two sexes are frequently to be noticed. When the male is fully equipped for flying, the female may be without wings, or even, as in the case of the glowworm, without elytra; and whenever there is any decided difference in coloration, it is almost invariably the male which displays the brightest and most conspicuous colors. The great projecting horns and processes on the head or prothorax which give so grotesque an appearance to many beetles, are generally wanting or only feebly developed in the females; and these and other differences are sometimes so strongly marked that it is difficult to recognize in the two sexes individuals of one and the same species.

The larvæ of beetles do not in outward appearance exhibit anything approaching the great diversity seen in the perfect insects. They seldom display conspicuous markings, and are mostly of dingy white, brownish, or black colors. The external structure and form vary sufficiently to make it possible to tell to what family of beetles, or division of a family, a larva belongs; but, so far as species are concerned, our knowledge of the larvæ is extremely limited, and applies to a relatively very small proportion of the whole number of known species of Coleoptera. In the weevils, and some other beetles, the larvæ are soft white grubs with scarcely any trace of legs, but in most of the other larvæ the legs are fairly well developed, though not so completely as in the perfect insects. The head is always horny, and furnished with jaws for biting and grinding solid food. Exceptionally, as in the carnivorous larvæ of some water beetles, the mandibles are adapted for sucking up the juices of the animals on which these larvæ prey. The antennæ are short and few jointed, and in some cases quite inconspicuous. Eyes, when present, are always in the form of ocelli, which are grouped together in varying number on each side of the head. The head is followed by a series of rings or segments, of which the first three — scarcely different in form from the rest — constitute the thorax, and give attachment to the legs. A pair of prolegs is sometimes present on the last segment, but in beetle larvæ the intermediate segments never carry those false legs, which are so often found in the caterpillars of Lepidoptera and Hymenoptera. The spiracles — which are mostly hidden by the elytra in the perfect insects — are generally quite conspicuous in the larvæ, and appear as a row on each side of the body. Their number varies; and in those aquatic larvæ which breathe by means of tracheal gills they are altogether wanting. When about to pupate some larvæ construct cocoons of earth, or, in the case of wood-boring species, they may make a shell out of fine chips and dust glued together with a sticky secretion. The pupæ, whether inclosed in a cocoon or not, are inactive, and show all their appendages lying freely against the body, with each appendage wrapped round by its own special covering of integument. The larval existence of beetles varies from five or six weeks in some groups to almost as many years in others; and when conditions arise to interfere with the proper nourishment of the larvæ, the period may be unduly prolonged. Some of the wood-boring

Zabrus gibbus and its larva. (Natural size.)

BEETLES IN A FLOOD.

larvæ seem to live an exceptionally long time. There is at the present time in the Natural History Museum in London a block of wood containing a living longicorn larva, which for the past five or six years has been feeding and burrowing in the wood. The larva was brought to the museum in a boottree, which its owner previously had in constant use for over fourteen years. Other cases are on record in which beetles have been seen to emerge from furniture in houses, after having apparently passed an even more prolonged larval existence.

Beetles, whether from the extent of their numbers or the variety of their shapes and instincts, are well qualified to play an important part in the economy of nature. Their chief function is that of universal scavengers. Not only do they dispose of the smaller quantities of dead and decaying animal and vegetable matter passed over by larger animals, but, by their own peculiar methods, they are enabled to attack and clear away even the carcasses of quadrupeds of large size, and the dead trunks of the largest trees. Owing to the compactness of their shape, and the solidity of their outer covering, they are adapted for a much greater diversity in modes of life than is possible for insects of other orders. Besides groups fitted to act as scavengers, we find further series of forms that live in, and prey upon, all kinds of plant life. There are groups again, either of terrestrial, arboreal, or aquatic habits, which seek for, and prey upon living animales of the smaller kinds. Some beetles live within the depths of the darkest caverns; and in such cases, having no use for eyes, they are generally blind. Others are to be found dwelling as "guests" in the homes of the ants and termites. Although the beetles cannot boast of such a long line of ancestry as the cockroaches and other Orthoptera, yet their records go back to an early period in geological history. There is no certain evidence that they existed in Paleozoic times, and their first appearance has not been traced farther back than the beginning of the Secondary epoch. The earliest undoubted fossil remains of Coleoptera occur in the Swiss Trias, and from this period onwards fossil beetles are to be met with in greater or less abundance in rocks of different ages. They are especially well preserved in amber; and from the Tertiary amber beds on the Baltic thousands of specimens have been collected.

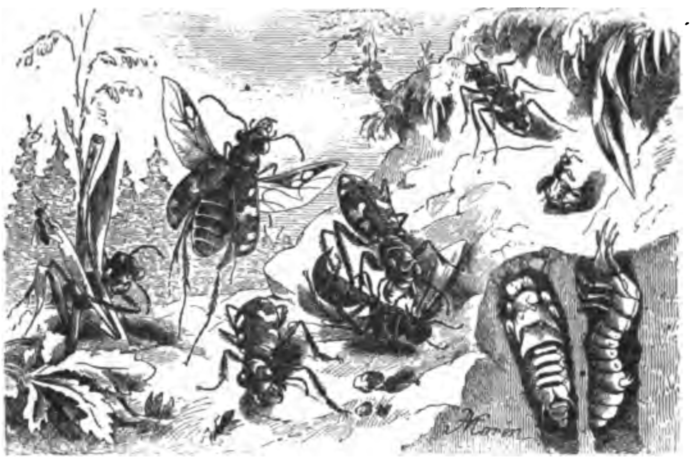
Of the beetles now existing, quite one hundred and thirty thousand different species have been described, and, considering the rate at which new species are being yearly added, it is probable that before the end of the century the number of named species will fall little short of one hundred and fifty thousand.

SECTION PENTAMERA

Beetles in which all the tarsi are five jointed. In this section there comes first a great tribe of beetles, which, on account of their carnivorous tastes and predaceous habits, are known as the Adephaga. Their whole organization seems well adapted to enable them to capture and devour their prey, and it is in the modifications directed to this end that some of the chief distinguishing characteristics of the tribe are to be found. Their legs are fitted for speedy locomotion, and their jaws for the cutting and tearing operations to which they are usually applied. The mandibles are acutely pointed and have sharp cutting edges; and the inner lobes of the max-

illæ are hard and hooked at the end. The outer lobes of the maxillæ are two jointed and slender, and resemble palpi; which explains the fact that these beetles are often described as having three pairs of palpi. The antennæ are usually simple, and never clubbed. The tribe is divided into the Geodephaga and Hydradephaga, one subtribe containing terrestrial, the other aquatic forms.

The *Cicindelidæ* consist of about one thousand known species, which are distributed throughout the world, but are much more abundant in tropical than in temperate or cold countries. In Europe only two genera are represented — *Tetracha*, which comprises nocturnal and twilight-loving species, and *Cicindela*, whose species are found in the hottest and sunniest places. The tiger beetles are extremely pretty insects of remarkably active habits, and exhibit the predaceous type of structure to perfection. Besides possessing great speed of foot, most of them make ready use of their wings, and they are further characterized by large and prominent eyes, and mouths well adapted for seizing and holding their prey, the mandibles being long and provided with a number of sharp teeth, while the inner lobe of the maxillæ is furnished with a movable claw or hook at the tip. The fact that this hook is movable and not firmly fixed to the blade of the maxillæ, affords a means of distinguishing the tiger beetles from all the other beetles of the tribe Adephaga. More than half of all the known species of the family belong to the single genus *Cicindela*, and this is the only genus which is cosmopolitan. With the exception of a few species of an almost entirely ivory-white color, the *Cicindelidæ* exhibit reenish, bronzy, or darker metallic tints, frequently varied with white or pale yellow spots and bands, which in the case of a great many species run together to form more or less intricate and pretty patterns. While their shape is usually such as is shown in our figure of *C. hybrida*, we get, on the other hand, remarkable exotic forms, in which the body is narrow and elongated, and broadest toward the hinder end. *Collyris* and other genera of the various Oriental countries — where the species are found pursuing their prey on the trees in the forests — afford examples of this type. From its great resemblance in color and form to *Collyris*, a rare and curious longicorn beetle, found in the same localities, has been named *Collyrodes;* and it has been remarked by Mr. Wallace that beetles of the family *Cicindelidæ* are among those most frequently mimicked by other beetles.



TIGER BEETLES.
Cicindela hybrida (with larva and pupa slightly enlarged); *Collyris longicollis* (enlarged).

In external structure the carnivorous ground beetles (*Carabidæ*) approach the *Cicindelidæ*, from which they may in most cases be distinguished by their general shape, as well as by the fact that they never exhibit the coloration and markings characteristic of that family. Other points of difference may be seen in their less prominent eyes, in the absence of an articulation in the hook of the maxillæ, and in the shape of the mandibles, which, though occasionally long, do not exhibit the slender curved form and sharp dentition met with in the tiger beetles.

The number of species of *Carabidæ* at present known can scarcely be less than eleven thousand. This family seems better represented in temperate and colder regions than within the tropics, though species, in more or less abundance, are to be found in every country and island of the world. While the species are almost all predaceous in their habits, we find them under a variety of different forms and with several distinct peculiarities of structure, many of which are to be regarded as special adaptations to the various situations in which the insects hunt for their prey.

The *Carabidæ* like all other beetles have their enemies, but we never find in this family any of those mimetic and protective disguises that are so commonly met with in certain other groups; and to escape from their enemies the ground beetles have mostly to rely upon their speed of foot, or the readiness with which they can take to flight or disappear among the herbage. Many species are, however, provided with anal glands that secrete an acrid or stinking liquid which is sometimes ejected with considerable force when the insect is handled. In the "bombardier beetle" (*Brachinus crepitans*) and others of the same group, the secretion is volatilized on emission, and issues as a little cloud of smoke, which is accompanied at each discharge by a slight sound; and when the insect is irritated it repeats the discharge several times in succession, but each time with diminished force. The "bombardier" is a rusty red species, with dull blue-black elytra, and a narrow head and prothorax, and is pretty common, especially on chalk, in different parts of the south and southeast coasts of England. Among those species of the family that in habits and general appearance most closely resemble the *Cicindelidæ*, are the little beetles of the genus *Elaphrus*. These love to run about in the rays of the sun, not so much in dry places, as on the muddy banks of rivers, on the sands of the seashore, and in other damp situations. They have large prominent eyes, a narrow prothorax, slender legs, and curiously marked elytra. This genus is confined to the Northern Hemisphere. The species which we figure, *Elaphrus riparius*, like some other beetles of the family, is able to produce a stridulating noise by rubbing the back of its abdomen against a projecting nervure on the under side of the elytra. Those tiny little beetles of a glistening bronzy-black appearance, and with beautifully sculptured elytra, which are to be seen on almost any bright day in the spring or summer, running quickly over garden beds or paths, belong to the genus *Notiophilus*, and are some of the smallest species in the whole family. The genus *Carabus*, after which the family is named, contains over three hundred species, and is somewhat remarkable in its distribution; for, with the exception of

Elaphrus riparius (enlarged.)

a small group of species found in Southern Chili, it is restricted in its range to the north temperate zone. Six or seven species are found in Britain; *Carabus violaceus* and *C. nemoralis* are perhaps the two most frequently met with, being abundant in gardens and fields in almost every part of the country. The first is nearly smooth, of a dull blue-black color, with purplish borders to the thorax and elytra, and is of about the same size as *C. nemoralis* (represented in the figure on p. 3088). The latter has a purplish thorax and bronzy elytra, marked with a few rows of conspicuous punctures. Another species which we figure, *C. auratus*, is very rare in England and doubtfully indigenous, but in France it is common and does much service by destroying the cockchafers and their grubs. The genus *Calosoma* approaches *Carabus* in many of its characteristics, but may be easily distinguished by its shorter, broader, and more rounded prothorax, and the greater relative width of its elytra. *Calosoma inquisitor*, though rare and found only in parts of England, may be regarded as a true British species; but the species figured (*C. sycophanta*) is only an occasional visitant to this country and cannot be considered indigenous. The *Carabidæ* as a whole, though sufficiently varied in their external structure, do not exhibit any very unusual or striking peculiarities of form, and the species already considered, with a few more presently to follow, may be taken as typical of the commoner forms met with throughout the family. In the genus *Mormolyce* we have, however, a remarkable exception. The species of this strange genus — three in number, and all very much alike — have been found in Java, Sumatra, and other East Indian islands. They are of a pitchy-brown color, and have the body much flattened, and the head greatly elongated, while their antennæ are also very long; but, as will be seen from our figure, the chief peculiarity in the appearance of these extraordinary insects is due to the great lateral expansions of the borders of the elytra, and the curious manner in which these expansions are prolonged behind. *M. phyllodes*, the best-known species, occurs in Java, Borneo, and the Malay Peninsula; and the people of Java, struck no doubt by its peculiar shape, call it "the violin." Some of the largest individuals of the species are nearly three and a half inches long, and measure more than an inch and a half across the broadest part of the elytra. We have alluded, in our introduction, to the burrowing habits of some of the *Carabidæ*. The *Scaritinæ* are a group that possess such habits, and the accompanying figure of *Scarites gigas* will give an idea of the general form characteristic of nearly all the species of the group. The genus *Scarites* comprises a large number of species, all of a uniform black color, and most of them of a moderate size. They make their burrows in the banks of streams, the seashore, or other suitable places, and rarely leave them during the

Mormolyce phyllodes (from a small specimen).

Scarites gigas.
(Natural size.)

day, lying in wait for their victims at the mouth of the holes. The genus ***Zabrus***, which we have next to notice, forms, so far as its habits are concerned, one of those exceptions that go to prove the rule. For, while it is true that almost all the *Carabidæ* are carnivorous and predaceous insects, some at least of the species of *Zabrus* and a few others are largely, though probably not wholly, addicted to a vegetable diet. The species (*Zabrus gibbus*) figured on p. 3092 lives in cornfields, and has at different times committed great havoc among crops — wheat, barley, rye, etc., in various parts of Germany and Italy.

The *Dytiscidæ* or carnivorous water beetles resemble the *Carabidæ* in many of their structural features, and differ chiefly in the modifications undergone to fit them to an aquatic mode of life. Thus we find, as in the latter family, the mentum is

Dytiscus marginalis — 1. Male; 2. Female; 3. Eggs; 4. Pupa; 5. Larva attacking a tadpole; 6. *Hydrocharis caraboides*; 7. Its larva; 8. *Acilius sulcatus*, Female. (All natural size.)

usually broad and deeply emarginate in front, the outer lobe of the maxillæ is two jointed and palpiform, the antennæ are moderately long and slender, and the trochanters of the hind-legs are prominent. On the other hand, the antennæ are always smooth; the head is broad and fits deeply into the prothorax, while the latter is applied by a broad base against the elytra, so that the outline of the body is continuous, and the general shape more or less oval; the hind-legs, which with their tibiæ and tarsi flattened and furnished with rows of bristles, are adapted to serve as oars in swimming, are somewhat longer than the other legs, and come off from the body at a considerable distance behind them, while their coxæ appear as broad flat plates firmly joined to the metasternum, for parts of which they might at first sight be very readily mistaken. The males may be distinguished from the females by the shape of their fore-tarsi, in which the first three joints are strongly dilated, and

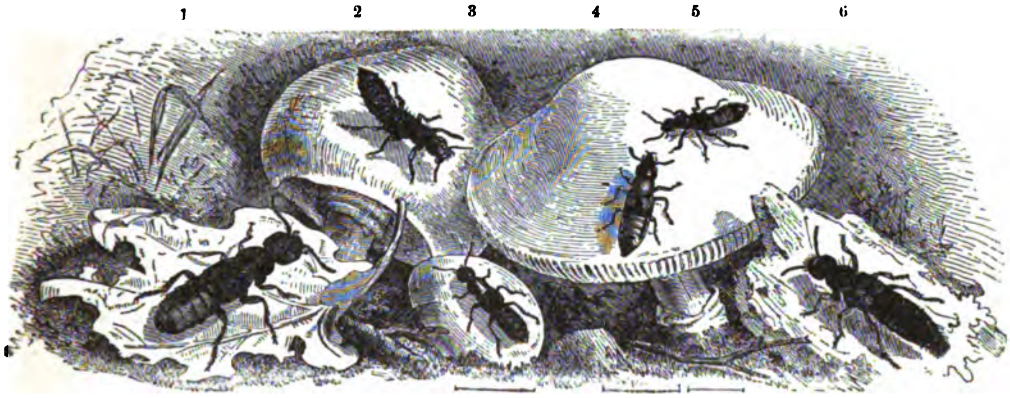
furnished underneath with sucker-like hairs; while in this sex also the back is generally smooth and glossy, the elytra of the females frequently have a ribbed or corrugated surface. The *Dytiscidæ* seem especially fond of stagnant waters, and some of the species are common objects in our ponds and ditches. They come to the surface when it is necessary to take in a fresh supply of air beneath the elytra. These organs fit very closely against the sides of the body, and so prevent the air from escaping while the beetle is swimming about under the water; but the air meanwhile is being used up in breathing by means of the thoracic and abdominal spiracles. The beetles fly strongly, and on fine summer evenings may sometimes be seen winging their way to new quarters, a change which is often necessitated by the drying up of the pools in which they had previously been living. *Dytiscus marginalis*, one of the largest British species, is also one of the commonest and best known. Another common species, *Acilius sulcatus*, is also represented in our figure.

The *Gyrinidæ* or whirligig beetles are a small but very well-defined group, and in many points of structure are sharply distinguished from the other families of the tribe Adephaga. In their oval shapes they resemble the *Dytiscidæ*, though they are usually somewhat flatter below and a little more convex on the upper side. But in the relative proportions of the three pairs of legs they are entirely different. The fore-legs are long and slender, and when stretched out look like arms, whereas the two hinder pairs are short and broad, being modified for use as paddles in swimming. Another very distinctive feature is presented by the eyes, each of which is divided by a ridge on the side of the head into two widely-separated portions, one lying on the upper side of the head and the other underneath. These beetles appear, in consequence, to have four eyes; one pair, as it is said, though there is no proof of the fact, for espying objects above them, the other for looking at things in the water below. From the *Dytiscidæ* and *Carabidæ* they differ further in having their antennæ shorter than the head, and the outer lobe of the maxillæ either completely atrophied or else in the form of a slender spine. The *Gyrinidæ*, though widely distributed and represented in almost all parts of the world, include altogether rather less than three hundred known species. The genera are few in number and two only occur in Europe. Some of the British species, such as *Gyrinus natator*, are commonly to be seen in ponds and canals or "holes" in reedy sluggish streams, where the shiny little beetles attract attention by the ease and rapidity of their movements as they skim about on the surface of the water, performing a variety of intricate evolutions, some sweeping along in graceful curves, others going round in circles or spiral tracks, now all collecting together in groups, and then, if startled, suddenly darting off with amazing speed in every direction.

COMMON WHIRLIGIG BEETLE, *Gyrinus natator* (enlarged.)

The next beetles we have to consider are those which, on account of their abbreviated wing cases, are known as the Brachyelytra. This tribe to which, however, not all beetles with short elytra belong, contains a single very large family — the *Staphylinidæ*. Owing to the shortness of their elytra, and the usually narrow and elongated form of their bodies, the rove beetles have an easily recognized

and characteristic appearance. The head is generally large and flat with a narrow neck behind where it fits into the prothorax. The antennæ — composed of eleven, or occasionally twelve joints — are usually filiform, but are often slightly thickened toward the extremity, and in some cases end in a distinct club. Though prominent and conspicuous in a few genera, the eyes are, as a rule, raised but very little above the general surface of the head. It is interesting to note that ocelli, which are of such rare occurrence in adult beetles, are to be found in certain groups of this family; two ocelli being present in *Homalium* and its allies, and a single ocellus in the genus *Phlæobium*. The mandibles vary in form according to the habits of the species; they are usually strong, often sharply curved and pointed at the end, and of a distinctly carnivorous type. Attached to the base and running a little way alongside the inner margin of each mandible, there is to be seen in many species a narrow flexible plate fringed, or not, with hairs at the end. This piece, first made known by Kirby, who called it the *prostheca*, is rarely met with except in the *Staphylinidæ*.



BRITISH ROVE BEETLES.

1. The devil's coach-horse (*Ocypus olens*); 2. *Staphylinus pubescens;* 3. *Philonthus æneus;* 4. *Oxyperus rufus;* 5. *Pæderus riparius;* 6. *Staphylinus cæsareus.* (Nos. 3, 4, and 5, slightly enlarged.)

The ligula is narrow, and bears distinct paraglossæ; and the outer lobe of the maxillæ is never palpiform. The rove beetles are for the most part carnivorous, and prey upon all kinds of larvæ and other insects, as well as upon slugs, snails, and worms, but they feed largely on carrion, and to some degree on vegetable matter. Several species live in fungi, some in flowers, others under bark and in rotten wood, while in the case of certain genera, such as *Lomechusa* and *Atemeles*, the species are to be sought for in or about ants' nests. Some of these latter species are welcome guests, since, like the Aphides, they secrete a liquid which is eagerly swallowed by the ants; others may possibly act as scavengers. Among the species of the genera *Spirachtha* and *Corotaca*, which live with the Termites in South America, some are very remarkable from the fact that the females give birth to living young.

Many of the British species of beetles belong to this family. Every one has seen the devil's coach-horse, that long, black, ugly-looking but useful insect which is to be found under stones and earth, or roving about in gardens, and which when you attempt to stay its progress, by pointing with a stick or finger, stands with

threatening jaws and upturned tail as if ready to accept the challenge. This species which, with a few others, is represented in the figure, is scientifically known as *Ocypus olens*, and is one of the largest of the rove beetles. Its habit of turning up the tip of the abdomen is not peculiar to it, but is common to nearly all the beetles of the family, which on that account are sometimes called cocktail beetles.

We come now to a series of small families, forming the group known as the Clavicornia or Necrophaga. This group, however, rests on no true scientific basis, and is more or less artificial in its character. Most of the species included in the group feed upon decaying animal or vegetable matter, hence the name Necrophaga. The antennæ exhibit in general a tendency to be thickened toward the tip, and in many cases the last three joints form a distinct club; but in some of the families antennæ of quite another shape are to be found. Though usually five jointed, the tarsi display in the number of their joints almost every variation met with in the Coleoptera.

The family of *Paussidæ* includes probably less than two hundred known species, the majority of which have been discovered in the tropics of Asia and Africa, though one species (*Paussus favieri*) occurs in the southwest of Europe. They are mostly reddish-brown insects, of rather small size, oblong form, and in general appearance little attractive, were it not for the extraordinary shapes of their antennæ. These organs are generally very broad and flat, in some species resembling a paper knife in shape; the number of joints varies from ten to two, and the last joint frequently has a bulbous or discoidal form. So far as at present known, all the species live in ants' nests, and, unless sought for in these situations, they are rarely seen except at night when they occasionally fly into rooms, attracted by the light from the lamps.

The tiny beetles belonging to the *Pselaphidæ* resemble the *Paussidæ* in exhibiting certain anomalies in their structure, and their lives are passed in similar obscure situations. But while the *Paussidæ* may possibly be related to the *Carabidæ*, the very short elytra of the *Pselaphidæ*, and the entirely horny nature of the dorsal plates of the abdomen seem to indicate an affinity with the *Staphylinidæ*. In other points of structure, however, these two families are different. In the *Pselaphidæ* the lobes of the maxillæ are soft and membranous; and the abdomen, which in one group (the *Clavigerinæ*) is composed of five segments, with the basal rings fused together, is quite incapable of the movements so characteristic of the rove beetles. The joints of the antennæ vary in number from eleven to six, or even two, and are in most cases clubbed at the end. While in one division of the family the palpi are usually composed of three or four joints, and are long and conspicuous, in the other they are one jointed and scarcely visible. The tarsi are three jointed, the first and second joints often very short, while the third is long and in many cases bears only a single claw. The *Pselaphidæ* are distributed throughout most parts of the world. They are to be found under stones, moss, dead leaves, and other vegetable refuse, as well as under the bark of trees, and in damp marshy situations; but the most interesting species are those which live in ants' nests. They are all of small size. The genus *Claviger*, comprising about eighteen European and one or two Asiatic species, has six-jointed antennæ, and is further remarkable for the fact that the long

cylindrical head is entirely devoid of eyes. The best-known species, *C. testaceus*, is in Britain met with chiefly in the nests of the common yellow ant (*Lasius flavus*), though on the Continent it is found also in the nests of other species. It is about a tenth of an inch long, yellowish brown in color, wingless, with the elytra fused together, and with a deep impression on the base of the abdomen. The relation between the ants and their guests is of a most interesting character. Whenever an ant meets one of these guests in a gallery of the nest, it gently touches and caresses it with its antennæ, and while the beetle responds in a similar manner, the ant sucks at the tufts of hair near the end of the beetle's elytra, and then licks the whole anterior surface of the back of its abdomen. The ants feed the beetles in very much the same way as they feed their larvæ. When the beetle is hungry it expresses its desire to be fed by licking an ant near the mouth, and occasionally stroking the sides of its head with gentle movements of its antennæ. During the process of feeding the beetle is passive; the ant moves its head gently to and fro, while the head of the beetle rests almost motionless in its mouth. The attention bestowed by the ants on the beetles is as great as that which they give to their own larvæ, and they frequently feed the hungry ones among them, before looking after the wants of their own brood.

Claviger testaceus, caressed by ants. (Greatly enlarged.)

The orange-banded burying beetles of the genus *Necrophorus* are probably the best-known members of the *Silphidæ*, though they are not to be considered the most representative, either in habits, size, or general appearance. The many genera of which the family is composed differ greatly in size and outward form, while the burying instinct is almost entirely confined to the genus *Necrophorus*. In nearly all cases, however, the antennæ, consisting usually of eleven joints, are thickened toward the tip or furnished with a distinct club; the prothorax is usually broad and flat, with sharply-defined lateral margins, while the elytra frequently do not reach to the tip of the abdomen; the coxæ of the four anterior legs are large, prominent, and conical in shape; and the tarsi are usually five jointed, though occasionally with a less number of joints. The carrion beetles are widely distributed, though chiefly characteristic of the colder and temperate zones. In the genus *Necrophorus* the antennæ terminate in an almost globular, four-jointed mass; the body is broadest across the ends of the elytra, which are abruptly truncated, leaving the tip of the abdomen exposed. The species of this genus are black in color, but in most of them the elytra are crossed by two broad orange bands. They feed upon dead animals of all kinds, and their habit of burying the smaller carcasses, such as those of mice, moles, small birds, etc., has gained for them the

name of "sexton" or "burying" beetles. Their mode of operation is to creep underneath and dig the earth away until they have made a hole big enough to receive the dead body; as the latter sinks, the loose soil closes over it and in time completely hides it from view. The females then lay their eggs in the carcass, which subsequently serves as food for the larvæ. These insects must have a very acute sense of smell, for in a very short time after a mole has been killed some of them may be seen hovering over the body, although not previously observed anywhere in the vicinity. Out of about a dozen species of *Necrophorus* occurring in Europe, seven are found in Britain, *N. vespillo* being perhaps the one which is most widely distributed. Most of the species of the genus *Silpha*—from which the family name is derived—are dark, sombre-looking insects, somewhat ovate in shape, the phothorax being broad and closely applied to the base of the elytra, while the elytra usually extend to the tip of the abdomen. The head is small, and when turned down is hidden under the pronotum. The beetles themselves are generally met with in or about dead animals, but some of the species display a partiality for a vegetable diet; thus in France the adult *Silpha reticulata* has been found to attack wheat, while *Silpha nigrita* devours strawberries in the Alps and Pyrenees. The larvæ of most of the species are somewhat like wood lice in shape, with the posterior angles of the abdominal segments sharply produced. Those of *S. opaca* and *S. atrata* are sometimes very destructive to the leaves of sugar beet and mangold wurzel.

Silpha atrata and larva. (Rather less than natural size.)

The *Trichopterygidæ*, or hairy-winged beetles, are exceedingly minute insects, the smallest, in fact, of all the beetles, many of the species being less than the fiftieth part of an inch in length. They are further remarkable on account of the structure of their wings. These organs are very long and narrow, each consisting of a strip of membrane attached to a horny stalk and fringed on each side with long and closely-set hairs.

Hister fimetarius and larva. (Natural size.)

The *Histeridæ* form a well-defined family, widely distributed, and numbering considerably more

than twelve hundred species. In color they offer little variety, being mostly either black, dark blue, or green, the elytra being occasionally spotted with red or yellow. They are compactly oval or oblong oval in form, and nearly always present a highly polished appearance. The antennæ are short, with a long basal joint and a very distinct terminal club, and, as a rule, are capable of being turned back into grooves beneath the thorax. The elytra are truncate at the tips, leaving the last two segments of the abdomen exposed; they are generally marked with a series of finely impressed longitudinal lines, the number and disposition of which afford useful characteristics in distinguishing between the different species of a genus. In the division of the family to which *Hister* belongs, the prosternum is produced in front, forming a prominent "chin-piece" which serves to protect the lower part of the head when the latter is retracted. In *Saprinus* the "chin-piece" is wanting.


Meligethes æneus (natural size and greatly magnified).

The *Nitidulidæ* have some resemblance in external form to the *Histeridæ*, though they are generally of smaller size, with their integuments less hard, and their colors a little more varied. The elytra are slightly truncate behind, leaving a variable number of the segments of the abdomen exposed. The antennæ are eleven jointed or, exceptionally, ten jointed, with the last two or three joints forming a knob; the maxillæ have, as a rule, but a single lobe, and the tarsi are five jointed, though in a few genera the males, at least, have only four joints in the posterior tarsi. Many of the species are found feeding and breeding in decaying vegetable or animal substances, such as rotten wood, bark, fungi, and in carcasses or bones; some frequent the exuding sap of trees; while a very large number are to be seen on flowers, among which are the brightly-colored little beetles of the genus *Meligethes*. The species figured (*M. æneus*) is one of the commonest, and met with chiefly on the flowers or leaves of cruciferous plants. In Germany these little beetles are well known, on account of the depredations they commit in crops of rape. A few days after emerging from their winter sleep, the beetles lay their eggs in the buds; in about a fortnight the larvæ are hatched and proceed to feed on the undeveloped or full-blown flowers; while later on they attack the young pods, to which they do more damage than the beetles themselves. The small family *Byturidæ* may also be mentioned here. The genus *Byturus* contains only four or five known species, which are confined to Europe and North America, and one of which is familiar to gardeners and others as the "raspberry beetle." This species (*B. tomentosus*) is somewhat oblong in form, from an eighth to a sixth of an inch in

length, of a dirty yellowish color, and covered with a yellow down. Though found on flowers of many different kinds, it is especially common on raspberry blossoms, and the cylindrical brownish larvæ sometimes do much damage to the flowers and fruit.

The *Dermestidæ* have a special interest, owing to the destructive habits of many of the species. The beetles themselves are small in size, oblong or oval in shape, sometimes nearly round, and usually clothed with fine closely lying hairs or scales, which frequently give rise to grayish or yellowish spots or bands on the elytra. The front of the head, except in the genus *Dermestes*, bears a single ocellus; the short antennæ, consisting usually of eleven joints, are clubbed at the end; the abdomen is entirely covered over above by the elytra; and the tarsi are always five jointed. While certain species are met with only on flowers, the majority live in dried animal matter—furs, skins, and the like, as well as articles of food, such as bacon and cheese. The perfect insects do comparatively little damage, the real depredators being the larvæ, including those of many species which in the adult state frequent flowers. The larvæ are little hairy creatures of a dark color, looking like small caterpillars, with the hairs sticking out straight and arranged more or less in tufts or bundles. The larvæ of *Anthrenus musæorum*, the so-called museum beetle, have to be carefully guarded against in museums, as they are very destructive to zoological collections and more especially to those of dried insects. *Attagenus pellio* is another very common species of this family, usually found in houses, and well known on account of the ravages of its larva in natural history collections, furs, hair-stuffed couches, etc. The larva is of a brown or red-brown color above, and covered with long hairs pointing backward; it is broader in front and tapers toward the hinder end, where it carries a tail tuft of very long hairs.

In the *Hydrophilidæ* the antennæ are short and composed of from six to nine joints, of which the first is relatively long, and the last three or so thickened in the form of a club; the mentum is a large shield-like plate without a notch in front; the lobes of the maxillæ are not toothed, and the palpi are long and slender, frequently much longer and more conspicuous than the antennæ. These characteristics afford a ready means of distinguishing these herbivorous water beetles from the carnivorous water beetles, to which in general shape many of them bear a close resemblance. The great length of the maxillary palpi has given rise to the name *Palpicornes* by which the family was formerly known. In the perfect state, all the members of the family feed upon vegetable matter; but it is only those of the subfamily *Hydrophilinæ*—of which the great water beetle, *Hydrophilus piceus*, may be taken as the type—that are truly aquatic in their habits; the second subfamily, the *Sphæridiinæ*, though including certain marsh-frequenting species, is composed mainly of land insects which are found chiefly in vegetable refuse or in the droppings of herbivorous mammals. Of the *Hydrophilinæ* some are found in stagnant, others in running water, but they are nearly all poor swimmers, while a large number progress by simply crawling along the surface film upside down; in their slow movements they present a marked contrast to the active predatory *Dytiscidæ*.

Having touched upon the principal families of the Clavicorn series, we pass to the Pectinicornia, a small tribe containing only two families, one of which has no

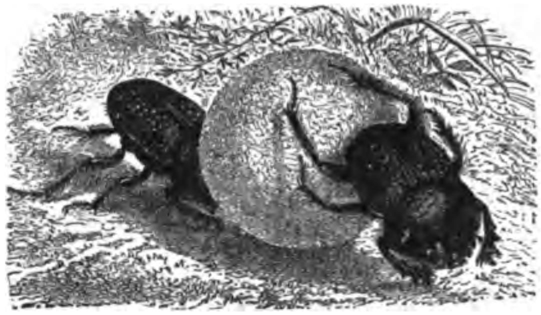
European representative, while both are somewhat limited in the number of their species. In the *Lucanidæ* the antennæ are ten jointed, with the first joint long and set at an angle with the rest of the antennæ, of which from three to seven of the last joints are furnished with rigid tooth-like processes on one side. The outer lobe of the maxillæ ends in a pencil of hairs, while the inner lobe has very often the form of a claw; the ligula is membranous or leathery in texture, and is attached to the inner face of the mentum; the elytra cover over the abdomen, which on the ventral side shows five or, in the male, six segments; and the tarsi are five jointed, with a long slender spur projecting between the claws of the terminal joint, and carrying at the end two long bristles. The male insects are remarkable for the massive development of their jaws, which in many cases are forked and branched. The common

GREAT BLACK WATER BEETLE.
(Natural size.)
1. Larva. 2. Male. 3. Female with egg cocoon.

stag beetle (*Lucanus cervus*), one of the largest of European beetles, may, in the case of full-sized males attain a length of over two inches, or, if the mandibles be included, more than three inches. It is most abundant in the neighborhood of oak woods, and in England is not uncommon in the southern counties, where the males may be often observed on the wing on fine summer evenings, flying with a loud hum.

The *Passalidæ* are a small family of about two hundred known species, which are almost entirely restricted to the warmer parts of the world, the greater proportion being found in America. In the form of the antennæ and in some other respects they show an affinity with the *Lucanidæ*, though easily distinguished by the characteristic of the mouth parts. The ligula is horny, and lies in a deep quad-

rangular emargination in the mentum; the lobes of the maxillæ both resemble claws; and the mandibles offer a peculiarity of structure met with in no other family, each being provided with a movably articulated tooth placed close to the basal molar surface.



BURROWING BEETLE, *Scarabæus variolosus*.
(Natural size.)

The Lamellicornia — comprising the burrowing beetles, cockchafers, and a host of other forms, differing both in habits and external structure — are represented in all parts of the world, though relatively less numerous in Australia than in the other great regions. We have only to mention the goliath beetles of West Africa, and the elephant and hercules' beetles of tropical America, to indicate the great size attained by some of the species; while as regards beauty and brilliancy of coloration no beetles can rival many of those belonging to the two subfamilies *Cetoniinæ* and *Rutelinæ*. The male stag beetles, as we have just seen, are distinguished by their large heads and monstrous jaws, but in the males of the present family it is, as a rule, the prothorax which is greatly enlarged or otherwise modified in form, and often furnished, like the head, with processes of various kinds, sometimes short, in others taking the shape of huge curved or branching horns. The family admits of two principal divisions. In the first division the ligula of the lower lip is more or less membranous and distinct from the mentum, and the spiracles of the abdomen are all situated in the connecting membrane between the dorsal and ventral plates. Among these we may mention the genus *Scarabæus*, over sixty species of which are known, most of them African, some occurring in Asia, and a few, including *sacer*, one of the sacred beetles of the Egyptians, found also in South Europe. Among the coprophagous species, met with in Great Britain, those of the genus *Aphodius*, which represents a second subfamily, are the most numerous. They are somewhat oblong in form, as shown in our figure of *Aphodius fossor*, one of the largest and best-known species, and are usually shining black, though in many the elytra are of a reddish or yellow color, in some cases spotted with black. A type of another subfamily is found in the genus *Geotrupes* of which we have in this country several species, including the well-known "dumbledor" or "shardborne" beetle (*G. stercorarius*). The species almost all exhibit dark blue or black colors, and in most cases the sexes differ little in external form; but in *G. typhœus*, the male is distinguished by having three

Scarabæus sacer.
(Natural size.)

Aphodius fossor,
with larva.
(Enlarged.)

horns projecting from the prothorax. The plant-feeding or phytophagous subfamilies belong to the second division of the *Scarabæidæ*. In these the ligula is consolidated with the mentum, and the abdominal spiracles are placed, some in the connecting membrane between the dorsal and ventral plates, the others on the sides of the ventral plates. One of our most familiar insects, the common cockchafer, gives a good idea of the general form and style of coloration prevailing in the subfamily *Melolonthinæ*, while in habits also it resembles other species of the same group. As examples of some of the other *Melolonthinæ* we figure *Polyphylla fullo*, one of the finest European species, which, though not indigenous to Britain, has occasionally been found on the south coast, and — on p. 3108 — *Rhizotrogus solstitialis*, a common British insect, commonly known as the summer chafer. The *Rutelinæ* have some resemblance in external form to the *Melolonthinæ*, but can in general be easily recognized owing to the difference in length between the two claws of each of their tarsi. The *Dynastinæ* are mostly confined to the warmer parts of the world, and chiefly remarkable on account of the great sexual differences exhibited by the species. In the hercules' beetles (*Dynastes hercules*), of the West Indies and tropical America, the male is sometimes over five inches long. The elephant beetle is a more massive insect, though, having relatively much shorter horns, its total length is not so great. As compared with other species of the subfamily the European rhinoceros beetle (*Oryctes nasicornis*), figured on p. 3108, is very modest in its proportions. Our next subfamily, the *Cetoniinæ*, stands unrivaled among the Coleoptera for the loveliness of coloration displayed by many of its species. The goliath beetles belong to this subfamily. In some of the genera, such as *Ceratorrhina* and *Goliathus*, the males may be recognized by the shape of the head, which is often excavated above, and furnished with hooks or horns, as shown in *C. smithi* on p. 3109.

MALE OF *Geotrupes typhœus*.
(Natural size.)

The *Buprestidæ*, together with the click beetles (*Elateridæ*), and a few smaller families, constitute the tribe Serricornia. Distinguished chiefly by their serrated or flabellated antennæ, the beetles of this tribe agree also in having the tarsi five jointed, and the prosternum prolonged behind and fitting into a cavity of the mesosternum. They are generally of an elongated form, with the elytra narrowed from the base to the tip and completely covering the abdomen. The *Buprestidæ* have short, serrated antennæ, composed of eleven joints, which, with the exception of three or four nearest the base, are covered on special areas with very minute pits supposed to be of an

Polyphylla fullo, male.
(Natural size.)

olfactory nature; these areas may be spread over nearly the whole of each joint, or confined to one side or the end of the joint, and their position affords one of the most important characteristics used in the classification of the family. The family is divided into three principal groups—the *Julodinæ*, *Chalcophorinæ*, and *Buprestinæ*. The first group is chiefly restricted to Africa and the East Indies. The *Chalcophorinæ* are more widely distributed, and include many of the finest species of the family, such as the *Euchroma gigantea* of South America, and the species of *Catoxantha* found in the East Indies. *Chalcophora mariana* — figured on p. 3109 — occurs in many pine forests of the Continent, and is one of the largest European species. The *Buprestinæ* are more numerous than the other two groups, and are found in all parts of the world.

SUMMER CHAFER.
(Natural size.)

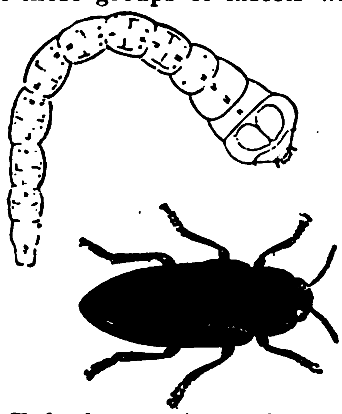
The click beetles are, as a rule, narrower and more elongated than the *Buprestidæ*, and differ also in having the posterior angles of the pronotum sharply produced behind, and the prosternal process laterally compressed and slightly curved, with its point resting in a deep cavity in the mesosternum. Their antennæ — consisting of eleven, or rarely twelve, joints — are usually serrate, though in many cases, especially in the males, they are either pectinate or flabellate. These beetles owe their name of skipjacks to the power they have, when fallen on the back, of springing into the air and alighting on their legs again. The larvæ of some species eat into soft succulent roots and tubers, and in this way prove destructive to many of our cultivated plants. These pests are well known to farmers under the name of wireworms. The larva of *Agriotes lineatus* is one of the worst, being destructive not only in the fields but also in the kitchen garden. It is of a pale yellowish-brown color, differing little in general appearance from the larvæ of other species, and lives for probably four or five years, passing then into a pupa, which remains concealed in the ground for a few weeks before changing into the perfect insect. Among the exotic members of this family, the most remarkable are the fireflies, found in the West Indies and America. There are several species of these beetles, all belonging to the genus *Pyrophorus*, one of which, *P. noctilucus*, is illustrated on

RHINOCEROS BEETLE, male.
(Natural size.)

p. 3110. They have a dark brown or reddish-brown color, obscured by a covering of short gray hairs, and may be easily recognized by the two slightly-raised yellow spots placed near the hind angles of the prothorax. In the living insect these spots glow with a rich yellowish-green light. A stronger but more diffused light of a reddish color is given off from the abdomen when the beetles are flying.

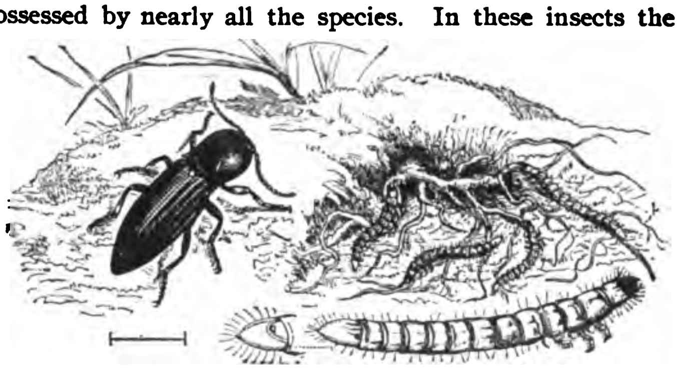
Ceratorrhina smithi, male.

The remaining families of the section Pentamera are included in the tribe Malacodermata. The beetles of this tribe are distinguished by having the elytra less solid and compact, and the body in general softer and more flexible than is usual in other groups. The *Lycidæ* are deserving of notice, inasmuch as they form one of those groups of insects which are most frequently mimicked by species of other families. They have a characteristic appearance, owing to the small size of the head and prothorax, as compared with the greatly expanded elytra. To their unusual shapes these beetles generally add a conspicuous coloration; tawny yellow and red, varied in many cases with black spots and bands, being the predominant colors throughout the family. They are found on the flowers and leaves of trees, and are sometimes seen in great abundance; and it is said that they secrete a nauseous liquid, which gives them immunity from the attacks of in sectivorous animals.



Chalcophora mariana and larva. (Natural size.)

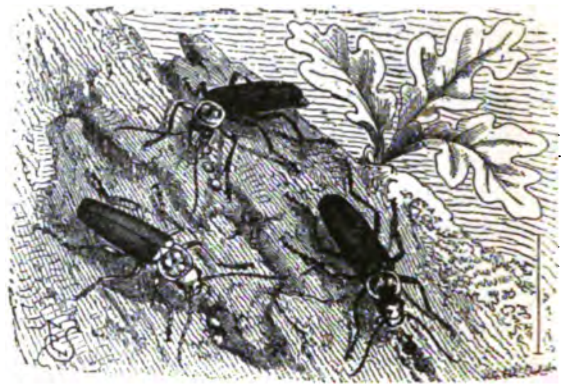
The *Lampyridæ* are remarkable on account of the luminous properties possessed by nearly all the species. In these insects the head is small and, being retracted under the pronotum, generally invisible from above; the eyes are large, especially in the males, the mandibles small but sharply pointed, and the antennæ come off close together from the front of the head. The phosphorescent organs are situated in the abdomen, their position being shown in most of the species by pale yellowish or whitish areas on the ventral surface of certain of the segments. These beetles are found



Agriotes lineatus and its larva — the well-known wireworm. (Both much enlarged, but the larva shown also natural size.)

in nearly all parts of the world, though most numerous perhaps in tropical America. In *Lampyris* and certain other genera the females are frequently apterous. The

THE WEST-INDIAN FIRE-FLY, *Pyrophorus noctilucus*.
(Natural size.)



Telephorus fuscus.
(Slightly enlarged.)

female of *Lampyris noctiluca* — our native glowworm — is not only without wings, but has even no trace of elytra, so that in appearance it is not unlike the larva of the same species, though it may be distinguished by its broad semicircular prothorax, its more fully-developed legs, and much greater luminosity. In the genus *Lucicola* — which is represented by two or three species in South Europe — both sexes are winged, and the males are even more luninous than the females.

Clerus formicarius, with larva and pupa.
(All enlarged.)

Trichodes apiarius.
(Enlarged.)

The *Telephoridæ* are distinguished from the two preceding families in having the head more exposed, the bases of the antennæ more widely separated from one another, the pronotum somewhat square in shape, the maxillary palpi ending in a hatchet-shaped joint, and the mandibles longer and often bifid at the end, or toothed on the inner side. Some of them are among the commonest and most familiar of our insects, — being known to schoolboys as "soldiers" and "sailors," — and few of our readers can fail to recognize the species figured. This species (*Telephorus fuscus*), and a few others of the same genus, — some of which are of an almost entirely yellowish-red color, — are very plentiful on flowers at certain times of the year.

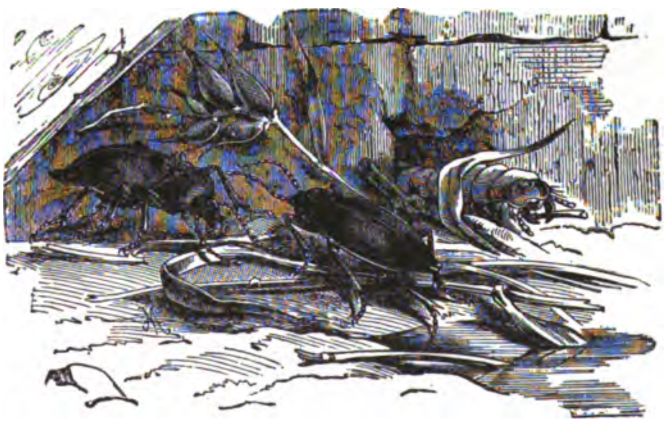
THE DEATHWATCH BEETLE, *Anobium tessellatum*.
(Enlarged.)

The *Cleridæ* are generally brightly colored, of cylindrical form, with the prothorax narrower than the elytra, the eyes notched in front, the antennæ either serrate, pectinate, or clavate, and the tarsi furnished underneath with membranous lobes. *Clerus formicarius* is very abundant in pine forests, where it plays a useful part in hunting for and devouring wood-boring beetles; while the larva is still more active in following under the bark the larvæ of various kinds which are there to be met with. The second species figured (*Trichodes apiarius*) hunts for its prey on flowers, especially those of the *Umbelliferæ*, and the larvæ are found in beehives, where they devour many of the young brood.

The *Ptinidæ* are all small insects, usually of a somewhat cylindrical form, rounded at each end, and with the head retracted under a hood-like covering, formed by the prothorax. They are obscurely colored and chiefly interesting on account of their mischievous propensities. In the larval state *Ptinus fur* is very destructive in herbaria, and natural history collections generally. The best known of the *Ptinidæ* are the deathwatch beetles of the genus *Anobium*, to which we have already referred at the beginning of this chapter. These beetles seldom show themselves openly, so that to most people they are only known by the sounds they produce, or the holes with which the larvæ riddle furniture and the woodwork of houses. The holes with which old books are sometimes seen to be perforated are also made by the larvæ of a species of *Anobium*, which for this reason are known as bookworms.

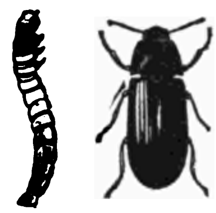
SECTION HETEROMERA

The Heteromera are those beetles in which the tarsi of the fore- and middle-legs are five jointed, those of the hind-legs being four jointed. The *Tenebrionidæ* exceed in number of species the rest of the Heteromera together. The antennæ are inserted under a projecting angle or ridge on each side of the head, and composed of eleven or, exceptionally, ten joints, of which the third is generally the longest; the coxæ of the front legs are usually rounded, with their sockets separated by a fairly broad prosternal process, and completely closed in behind; and the claws of all the tarsi are simple. Many of the obscurely colored species are without wings, and frequently have the elytra fused together. The churchyard beetles (*Blaps*) and the meal worm (*Tenebrio*) are probably the best-known members of the family. *B. mucronata* is the commonest species in England;



CHURCHYARD BEETLE AND LARVA (natural size).

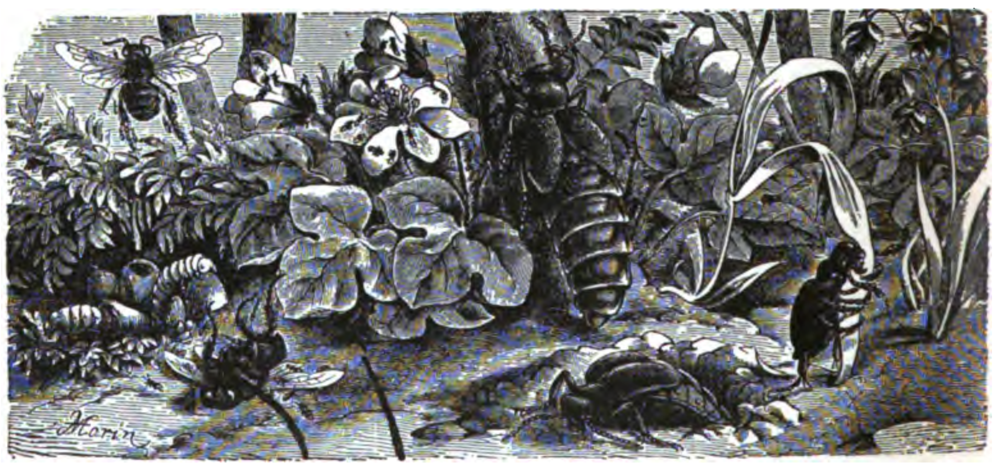
it differs from *B. mortisaga*, which also occurs, though rarely, in this country, in having shorter points to the elytra. Of the genus *Tenebrio* two species occur in Britain, one of which (*T. molitor*) is almost cosmopolitan in its range, having been carried in flour to nearly every part of the world. The larvæ, known as meal worms, are long and narrow, of a light yellowish-red color, with the integument hard, and the last segment conical in shape and ending into two slightly-diverging processes, armed each with a small black spine.



THE COMMON MEAL WORM AND ITS LARVA (enlarged).

The *Rhipidophoridæ* are a small but interesting family of beetles in which the wings are always more or less exposed, and not folded transversely as in most other groups, while the elytra are either very short (as in the genera *Rhipidophorus* and *Rhipidius*), or else triangular in form, meeting only at the base and diverging from one another behind.

The *Meloidæ* are chiefly distinguished from the other Heteromera by having the head abruptly constricted behind in the form of a short neck, the coxæ of the anterior and middle legs long and prominent, and placed close to one another in the middle line, and the claws of the tarsi accompanied each by a slender hook, so that they appear double. Many of the species possess vesicating or blistering properties, and the family is for this reason sometimes known as the *Vesicantia*.



OIL BEETLES AND LARVÆ.
(Natural size.)

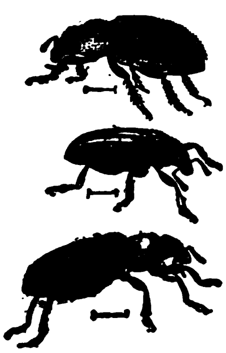
The larvæ are interesting on account of their habits and the changes of form they undergo in the course of their development. These changes are well illustrated in the case of the oil beetles (*Melöe*). The larvæ of these when first hatched from the egg are active little creatures furnished with six legs. They climb on to flowers, and wait in readiness to fasten themselves to the hairs of bees coming to gather the honey. In this way they get carried to the nest, where they devour the eggs of the bee. They now cast their skin, appear as little, maggot-like grubs, with much reduced legs, and feed on the honey intended by the bee for its own young. After a

time they change to the form of a pupa, from which, instead of the perfect insect, a third form of larva, somewhat similar to the second, emerges, while a further change is still required before the true pupal stage is reached. Seven species of *Melöe* occur in Great Britain, but, with the exception of one or two, are very rare. When handled or irritated they exude an oily-looking liquid of a yellow color from certain of their joints. This secretion, to which they owe their name of oil beetles, has a burning, acrid taste.

The *Stylopidæ* are remarkable little insects, which live parasitically in the bodies of wasps, bees, and bugs, and present a type of structure distinct from that of all other beetles. The males is a winged insect, with coarsely-faceted prominent eyes, large fan-shaped wings, and extremely small inconspicuous elytra; the first two thoracic rings are very short, while the metathorax is greatly elongated and covers over the base of the abdomen; the hind-legs are placed a long way behind the middle pair, and the tarsi of all the legs are membranous underneath, and without claws at the end. The female, on the other hand, is a grub-like creature, without legs, wings, or eyes. She never leaves the body of her host, and from her eggs active little six-legged larvæ develop, which make their way out and get carried into the nests of bees and wasps, where they bore into the bodies of the grubs. The *Stylopidæ* are very rarely seen, and the number of species known is small. They have been arranged in four or five genera, based upon slight differences in the structure of the males, all of which have the general appearance shown in our figure of *Xenos peckii*.

1. *Xenos peckii*—male; 2. Female.
(Both enlarged)

SECTION TETRAMERA



Sitones lineatus and allied species.

The *Curculionidæ* or weevils are distinguished from all other beetles by a few well-marked characteristics. The head is always produced in front in the form either of a short muzzle or a more or less elongated and narrow beak, which carries the mouth at its extremity; the prothorax rarely has sharp lateral edges, and the coxal cavities on the under side of that segment are always closed in behind by the extension inward of the epimera to meet in the middle line; and the antennæ are elbowed, with the first joint as a rule long, and some of the joints at the end forming a club. Though agreeing in a few essential characteristics, the weevils present considerable variety, not only in the form and structure of different parts, but also in the general shape of the body. They have been arranged

in a number of subfamilies, but it is impossible in a limited space to describe the various modifications of structure on which these divisions are based, and we must content ourselves here with a brief reference to some of the typical and more interesting forms. In the genus *Sitones*, we have examples of those weevils in which the snout is short and comparatively broad. *S. lineatus* is a well-known species which lives on papilionaceous plants, and frequently does much mischief by devouring the young leaves of peas and beans. It is a little yellowish-gray or drab-colored beetle with three pale lines along the thorax, and a number of rows of punctures along the elytra. Its color is due to a thick covering of scales, some of which, when looked at closely, are seen to have a golden tint.

PINE WEEVIL, WITH LARVA AND PUPA.

Weevils are, as a rule, most destructive during the larval state, the adult insects doing a comparatively small amount of injury to vegetation; but as regards *Hylobius abietis*, known as "the large pine weevil," one of the worst enemies of young conifers, the injury done to the trees is altogether the work of the beetles, while the grubs are quite harmless. The genus *Apion* comprises a large number of little, long-snouted weevils, having in general the form shown in our figure of *A. apricans*. Though the British species are numerous and some of them common everywhere on clover, trefoil, and other leguminous plants, they are seldom noticed owing to their small size. In *Apoderus*, *Attelabus*, and *Rhynchites* we have a group of genera which are interesting on account of the leaf-rolling habits of the females, and remarkable also, in the case of the first genus, for the great length of neck displayed by some of the species. The females deposit a single egg, or in some cases two or even three eggs in each of the little rolled-up leaf packages, which serve afterward both as a shelter and food supply for the larvæ. Three or four species of these leaf-rolling weevils are found in Britain. Our figure of *A. longicollis*, a Javan species, shows what an extraordinary length the neck may attain in the males of some of the tropical representatives of the genus, although in this species it is not nearly so long in proportion as in an allied form (*A. tenuissimus*) found in the Philippine islands. The nut weevil (*Balaninus nucum*) affords a strong contrast in the shape of its head to the species just mentioned. It will be noticed that in this weevil the head is very short behind the eyes, whereas the beak is greatly elongated, with the antennæ inserted near the middle of its length. The female lays her eggs in hazel nuts while the latter are still in a half-developed condition; she first pierces a hole in the soft shell of the nut, and then

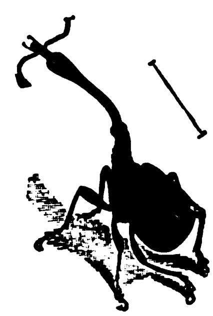
Apion apricans.
(Natural size and much enlarged.)

depositing an egg in the opening pushes it in with her beak. The grub feeds inside the nut, remaining in it until autumn, when it bores a round aperture in the shell, and, escaping from the nut, makes its way into the soil, where it surrounds itself with a cocoon formed of fragments of earth. The "apple-blossom weevil" (*Anthonomus pomorum*) is another species which, on account of its injurious habits, deserves some notice. It is about a quarter of an inch long, of a

LEAF-ROLLING WEEVILS.

1. *Attelabus curculionoides;* 2. *Apoderus coryli;* 3. *Rhynchites betuleti;* 4. *R. populi;* 5. *R. betulæ.* (Natural size.)

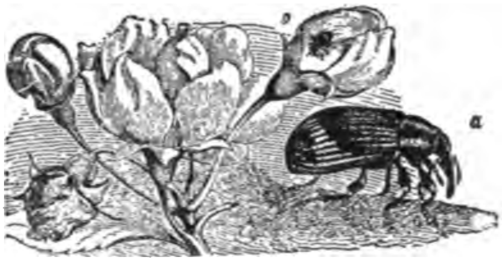
grayish-brown color, with an oblique white band on the elytra, and three whitish lines on the thorax. The female deposits her eggs in the unopened flower buds of the apple, and the larva by feeding on the stamens and pistil causes the bud to wither and die. In about fifteen days, the larva attains its full size, changing then to a pupa within the bud, and the beetle appears about eight days later and escapes through an opening which it makes in the side. A closely-allied species (*A. pyri*) proves injurious in the same way to pear blossoms. The cabbage-gall weevil (*Ceuthorrhynchus sulcicollis*) and certain species of *Baridius* attack cruciferous plants; the larvæ of the former live inside galls which they raise on the roots of cabbages and turnips, while those of *Baridius* may be found living in the lower part of the stem. The grain weevils, which are most numerous in tropical countries, are represented in Britain by two almost cosmopolitan species, the corn weevil (*Sitophilus granarius*) and the rice weevil (*S. oryzæ*). These are both small species, but belong to a subfamily (the *Calandrinæ*), which includes a number of the largest tropical weevils, such as the palm weevil (*Rhynchophorus palmarum*).



Apoderus longicollis. (Enlarged.)

The *Scolytidæ* and two other small families, the *Brenthidæ* and *Anthribidæ*, are associated with the weevils in the tribe Rhynchophora. The *Scolytidæ* are little beetles which live under bark, and often prove very injurious to trees. They have four-jointed tarsi, clubbed antennæ, and the head produced in front into a short muzzle. The females lay their

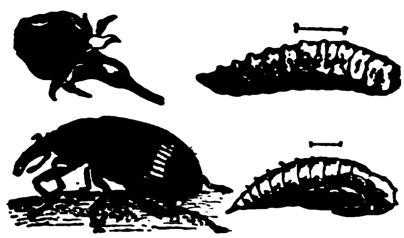
eggs along the sides of galleries which they burrow out under the bark; the larvæ when hatched make tracks at right angles to the mother galleries, and thus form curious and characteristic patterns.



PEAR-BLOSSOM WEEVIL, WITH LARVA AND PUPA (enlarged.)

NUT WEEVIL AND ITS LARVA.

The *Cerambycidæ* or Longicorns have in most cases a characteristic appearance by which they may be easily recognized, though, owing to a great variety in their form and structure, the family as a whole is not easily defined. Thus the great length of the antennæ to which these beetles owe their name is not always a distinguishing feature, for in many genera the antennæ are much shorter than the body. The Longicorns resemble the Rhynchophora in having the first three joints of the tarsi furnished underneath with a brush-like covering of hairs, and the fourth joint very small and hidden between the lobes of the third; but they are distinguished from that tribe by the fact that the epimera of the prothorax do not meet, while the head, though sometimes produced into a short muzzle, is never prolonged in the form of a beak. The larvæ all have a strong family likeness, and are quite unlike those of the *Chrysomelidæ*. They are of a dirty white or pale yellow color, with a



APPLE-BLOSSOM WEEVIL.
(Natural size and enlarged.)

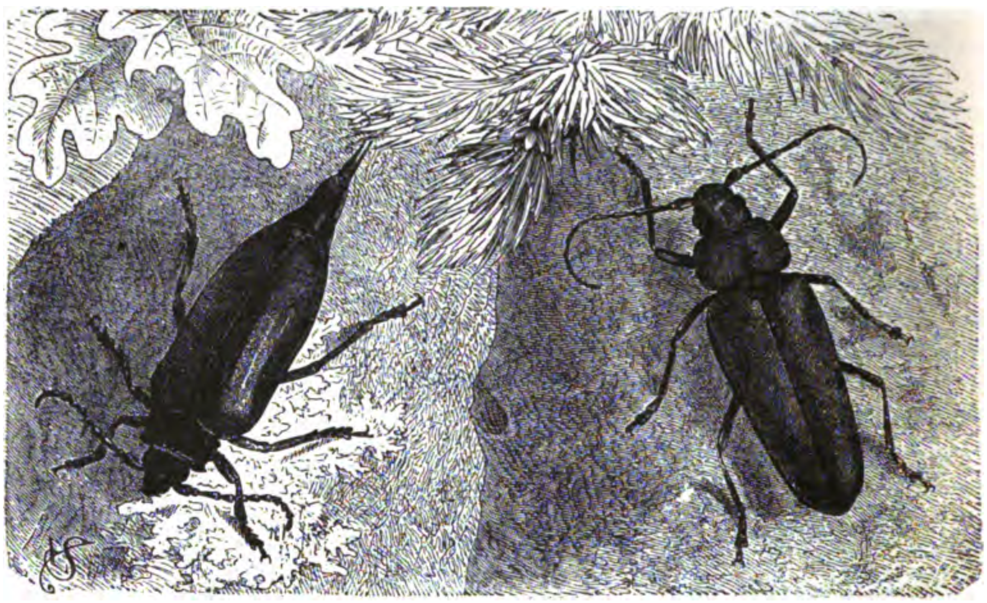
1. *Ceuthorrhynchus sulcicollis*; 2. *C. assimilis*; 3. *Baridius chloris*; 4. *B. cuprirostris*.
(The beetles all enlarged.)

rather soft skin, and in general form most resemble the larvæ of *Buprestidæ*. These larvæ all live in the interior of plants; some feeding just under the bark, while the great majority bore tunnels in the woody tissue, or live exclusively in the pith. The males have, as a rule, longer antennæ than the females, and may often be distinguished by the larger size of the eyes, jaws, or prothorax, or the greater length of the legs. The females are provided with a flexible ovipositor, which can be protruded some distance beyond the end of the body. In the subfamily *Prioninæ* the anterior coxæ are strongly transverse, and their sockets widely open behind, the sides of the prothorax are sharply edged, the palpi are never pointed at the end, and the front tibiæ are without a groove underneath. This subfamily is the least numerous in species, though many of these are distinguished for their great size. *Titanus giganteus*, a Brazilian species, sometimes measures over half a foot long, and is the largest of all known beetles, while the sawyer beetle (*Macrodontia cervicornis*) and other species occurring in tropical America, are not much smaller. Most of the *Prioninæ* are found in the warmer parts of the world. They are represented in Europe by *Prionus coriarius*, *Ergates faber*, and a few other forms. *P. coriarius* is the only species which occurs in England, and is not very common, being met with chiefly in oak woods, where the larvæ live in the trunks of rotten trees. The *Cerambycinæ* are widely distributed and include a very large number of species. They are, as a rule, narrower than the *Prioninæ*, and without sharp lateral edges to the prothorax, while the sockets of their front legs are seldom strongly transverse and are often rounded and completely closed behind. Most of the species have a stridulating area on the mesonotum, and by this means are enabled to produce sounds. This subfamily includes a number of very remarkable mimetic forms, some with broadly expanded elytra, and black and tawny colors resembling *Lycidæ*, others with the elytra greatly reduced in size, and the shape of the body modified in imitation of various Hymenoptera. The metallic-colored beetles of the group *Callichromides*, most of which are found in tropical countries, exhale a scent resembling attar of roses. In England this group is repre-

PALM WEEVIL.
(Natural size.)

Hylotrupes bajulus, with larva.
(Natural size.)

sented by the musk beetle (*Aromia moschata*), figured on p. 3119, a handsome insect of a golden-green or bronzy color, which is met with on willow trees. Among the European species of *Cerambycinæ*, the groups *Lepturides*, *Molorchides*, and *Clytides* are best represented. Some of the *Lepturides*, such as *Strangalia* and *Toxotus* are flower-frequenting insects, others like *Rhagium* are found on the trunks of pine trees. In the *Molorchides* the elytra are usually short or very narrow, and the abdomen slender and constricted at the base, so that many of the species have a resemblance to Hymenoptera. The European *Necydalis major* looks like a hornet, but in many of the tropical forms these resemblances are more pronounced. The *Clytides* are found on flowers, chiefly of the umbelliferous kind, and two or three species are among the prettiest of British beetles. Some of the *Clytides* and species of *Hylotrupes* and *Callidium* are occasionally met with in houses, being



Prionus coriarius, female; and *Ergates faber*, male.
(Natural size.)

introduced in the wood in which the larvæ feed. The *Lamiinæ* are more numerous than the other Longicorns, and distinguished by having an oblique groove on the lower side of the front tibiæ, the last joint of the palpi usually pointed at the end, and the front of the head in most cases turned down vertically, or sometimes even inclined backward, bringing the mouth close to the prosternum. The species of the genus *Lamia* are few in number and by no means typical of the subfamily; they are clumsy-looking, dull black insects, one of which (*Lamia textor*) is found on willow trees and in osier beds in some parts of Britain. In the genus *Acanthocinus* the antennæ attain their greatest length, being four times as long as the body in the male. *A. ædilis* is found in pine woods in Scotland, and is met with occasionally in other parts of Great Britain and even in London, where it is sometimes introduced in timber. Among the exotic species of this subfamily, the harlequin beetle

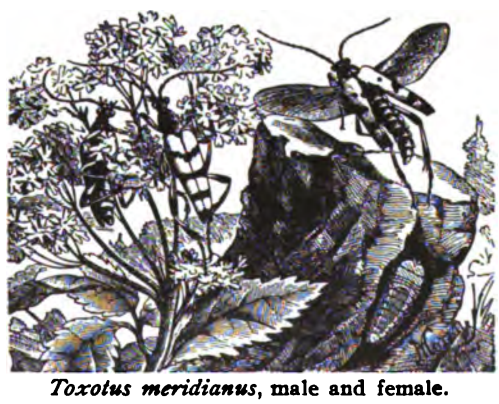
(*Acrocinus longimanus*) is one of the most remarkable, being distinguished, not only by its curiously variegated colors, but also by the extraordinary length of the front legs in the male.

1. MUSK BEETLE. 2. *Spondylis buprestoides*. (Natural size.)

Strangalia armata and larva. (Natural size.)

The *Brushidæ* are a small but widely-spread family of little beetles which are found chiefly on leguminous plants. The larvæ live in the seeds, eating up all the internal parts and changing to pupæ within the outer shell. These beetles were at one time classed with the weevils, but are now generally recognized as being more nearly allied to the next family. They are illustrated on p. 2963, where Fig. 1 is the pea bruchus (*Bruchus pisi*); Fig. 2, the bean bruchus (*P. rufimanus*); and Fig. 3, *B. granarius*, and larva; all of them being enlarged.

The *Chrysomelidæ*, more commonly known as the Phytophaga — though this name is equally applicable to many other beetles — all live upon plants, feeding chiefly upon the foliage, while some also attack the flowers. They are almost as numerous as the weevils, and in their own way quite as destructive to vegetation. The family is divided into four sections. The Eupoda include those forms which most resemble the Longicorns. Many of the beetles belonging to this section have thickened hind-legs, but instead of being active jumpers, as might be suspected, they are really very slow and awkward in their movements. In the males of the genus *Sagra*, the hind-legs are enormously developed, the species of this genus being for that reason sometimes known as kangaroo beetles. The *Donacinæ* live upon aquatic plants of various kinds; they have a bright metallic coloration, which in many species is veiled by a delicate covering of silky hairs, and their elytra are marked with rows of deep punctures. The larvæ feed under water upon the roots



Toxotus meridianus, male and female. (Natural size.)

1. *Rhagium indagator*, with larva and pupa case; 2. *Rhagium bifasciatum*. (Natural size.)

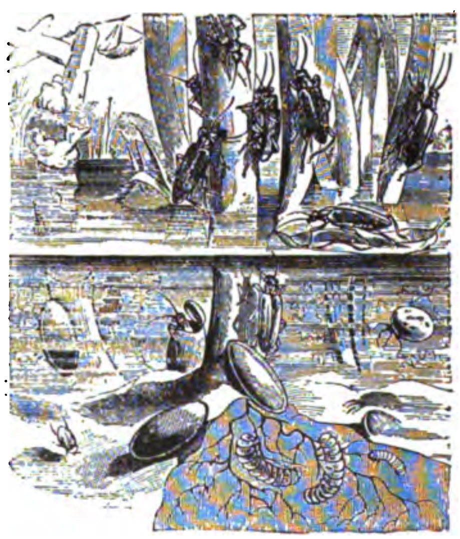
of the plants, and change to pupæ which are inclosed in oval cocoons. In the beetle of the section Camptosomata, the body is short, the head vertical and deeply sunk in the prothorax, and the abdomen slightly curved, with its middle segments contracted; the antennæ are short and serrate or pectinate in the first subfamily, while in the second they are rather long and filiform. The larvæ move about surrounded by a sack-like case, from which the head and anterior part of the body are free. They retract themselves completely within the case and close up the opening when about to undergo their metamorphosis. The Cyclica comprise four subfamilies, of which the first, the *Eumolpinæ*, is almost entirely composed of exotic species, though one of the few species found in Europe (*Bromius vitis*) is only too well known on account of the damage it inflicts on the leaves of the vine. With the *Chrysomelinæ* we come to the most typical forms belonging to the family. These beetles are distinguished by their oval and convex shapes, having in many cases a great resemblance to ladybirds (*Coccinellidæ*), while their colors are nearly always brightly metallic or otherwise conspicuous. Some of the species are very gregarious in their habits. *Lina tremulæ* is often found in large

Necydalis major. (Natural size.)

numbers in all its stages on the leaves of aspen; the larvæ are somewhat like those of ladybirds, and have the habit of exuding a strong-smelling yellow liquid from

1. *Lamia textor;* 2. Female of *A. ædilis;* 3. Male of *Acathocinus ædilis;* 4. *Saperda carcharias;* 5. *S. populnea.* (All natural size.)

the mouth and other parts of the body. The Colorado potato beetle (*Leptinotarsa decemlineata*) is very destructive to the potato crops in North America. The *Galerucinæ* are poorly represented in Great Britain, while of the flea beetles (*Halticinæ*) we have a large number of species, of which the best known are the turnip flea (*Phyllotreta nemorum*), and other little jumping beetles which attack cruciferous plants. The larvæ of the *Halticinæ* usually mine in the tissues of the leaf underneath the epidermis; in this respect differing from the larvæ of most of the other *Chrysomelidæ*. The Cryptostomata are distinguished by having the front of the head inclined backward so that the mouth is almost completely hidden. Two subfamilies are included in this section. The *Hispinæ* are remarkable for the sharp projecting spines with which many of the species are armed, while the *Cassidinæ* have the characteristic form to which they owe their name of tortoise beetles. In Great Britain, the tortoise beetles are represented by half a



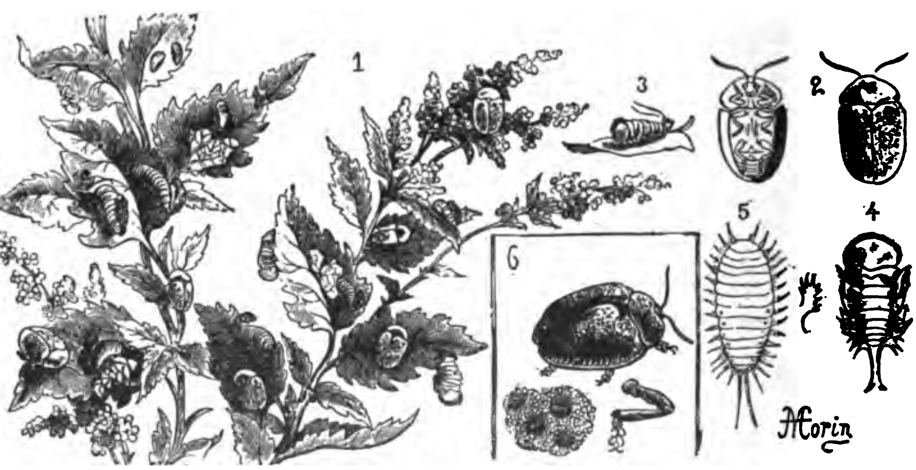
Donacia clavipes, with larva and pupa case. (Natural size.)

dozen or more species of the genus *Cassida*, one of which (*C. nebulosa*) in its different stages is illustrated in our figure. A Brazilian species (*Desmonota variolosa*), remarkable for its deeply-sculptured elytra and bright golden-green color, is also shown in the same figure.

COLORADO POTATO BEETLE IN ALL ITS STAGES.
(Natural size.)

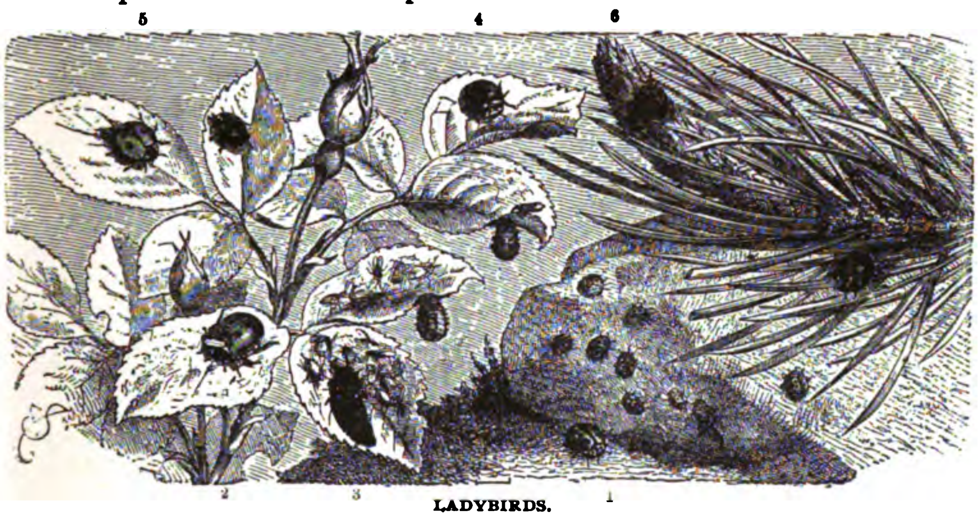
SECTION TRIMERA

Two families, of which one only need be noticed here, are included in this section. The *Coccinellidæ* or ladybirds are so familiar to everyone that it is quite unnecessary to describe their general appearance. They are resembled in shape by some other beetles, but in such cases the ladybirds may be distinguished by their three-jointed tarsi, clubbed antennæ, and the hatchet-shaped terminal joint of their palpi. These charming little insects have always been held in much respect, as the different names given to them testify, and it is well that it should be so. For while the species of a few genera (*Epilachna*, *Lasia*) are herbivorous in their habits, the great majority live — especially in the larval state — upon green fly and plant lice, and, by keeping these noxious insects in check, perform a useful service to man. The ladybirds are found in nearly all parts of the world, and over a thousand different species are known. Among several species occurring in Britain the two commonest are, perhaps, the large seven-spotted *Coccinella septempuncta* and the small two-spotted *C. bipunctata*. The latter varies in color to a great extent, so that between the



LIFE HISTORY OF THE TORTOISE BEETLES (*Cassidinæ*).
1. *Cassida nebulosa;* 2. The beetle (enlarged); 3. The larva (natural size); 4. The pupa, and 5, the larva (both enlarged); 6. *Desmonota variolosa*, with leg and portion of elytron enlarged.

typical form with red elytra marked with two black spots, and others in which the elytra are entirely black, one meets with almost every intermediate condition. The larvæ of these species may often be seen walking about on leaves that are infested with green fly. They may be recognized by their slate-blue color, marked with some yellow dots, and by the greed with which they devour the aphides. The larvæ, when about five or six weeks old, are ready to pupate. Fixing themselves by the tail end to a leaf, they cast their skin, and the pupæ, resting upon the cast-off larval skin, remain attached to the leaf. The beetles emerge about eight days later, so that the whole course of development from the egg to the perfect insect is completed in less than a couple of months.



LADYBIRDS.

1. *Micraspis duodecimpunctata* (natural size and enlarged); 2. *Coccinella septempunctata;* 3. Larva (enlarged); 4. *C. impustulata;* 5. *C. bipunctata* and dark variety; 6. *Chilocorus bipustulatus.*

CHAPTER V

JOINTED ANIMALS—*continued*

INSECTS — *concluded*

Orders NEUROPTERA, ORTHOPTERA, RHYNCHOTA, etc.

Characteristics of the Neuroptera THE Neuroptera form the last order of insects which undergo a complete metamorphosis in the course of their development. In this order it was formerly usual to include certain groups of insects, such as the dragon flies, May flies, white ants, etc., none of which pass through a period of prolonged inactivity, or pupal stage, before reaching the perfect condition. But although it is largely a matter of convenience whether these groups be placed, as they are in this work, in the order Orthoptera, or arranged in a series of separate orders, no one, taking into consideration the great difference in their mode of development, would now think of associating them in the same order with the true Neuroptera. The adult insects of the present order have their mouth organs, when fully developed, adapted to biting and grinding, and never formed for piercing or sucking; in which respect they differ from three of the other orders of the metabolous insects, namely, the Hymenoptera, Diptera, and Lepidoptera. From the Coleoptera they are easily distinguished by the structure of their fore-wings, which are never hard and horny like the wing cases or elytra of the latter. Both pairs of wings are membranous, and usually traversed by numerous, more or less closely reticulating, veins; whence the name of Neuroptera given to the order. The hind-wings are often very similar to the fore-wings, but sometimes differ considerably in size and shape. In one section — the caddice flies — they are capable of being folded like a fan, but in the other section (Planipennia) they always remain flat, and are spread horizontally or obliquely in repose.

CADDICE FLIES — SUBORDER **Trichoptera**

The caddice flies, forming the first of the two great divisions of the order, are in general appearance rather like some of the smaller kinds of moths; and since they differ a good deal from the typical Neuroptera, they are often treated as a distinct order. In their adult state they have two pairs of wings, in which the neuration is comparatively simple, with few transverse nervures. The wings are generally clothed with hairs, and the hind-wings usually shorter, broader, and less hairy than the front pair. When at rest, the hind-wings are folded fan-wise, with the fore-wings covering them over like a roof. The caddice flies have a rather small head, which bears two long, tapering, and many-jointed antennæ. They have round and

prominent eyes, and usually also three ocelli, placed on the forehead. With the exception of the palpi, their mouth organs are feebly developed. Their legs are long, and possess five-jointed tarsi; and the tibiæ are generally furnished with spurs, whose number and disposition are of considerable value in distinguishing the genera. These insects fly chiefly in the evening or at night, and, attracted by the light, frequently enter houses; some of the smaller species flying in swarms over water. The larvæ, with few exceptions, are aquatic in their habits; some being carnivorous, although most feed on vegetable matter. Found in streams, lakes, and ponds, or any piece of water in which plants grow, caddice worms, as the

VARIOUS FORMS OF CASES MADE BY CADDICE FLY LARVÆ.

1-5. Cases composed of sand and pebbles; 6. A case made of small snail shells; 7-10. Cases made of different parts of plants.

larvæ are called, are well known to anglers, by whom they are frequently used as bait. The eggs from which they are hatched are laid sometimes in the water, or on aquatic plants or trees overhanging water. Females have occasionally been captured with a coating of dry mud on their abdomen, showing that they had gone to some muddy pool to lay their eggs. The cases, made out of all sorts of materials, with which many of the larvæ surround their bodies, have long been objects of interest to the naturalist. Some larvæ pick up bits of sticks and leaves, grains of sand, and fragments of shells, or whatever else comes handiest, and fasten them together in a rough sort of fashion; but many exercise a choice in the selection of materials,

and exhibit great dexterity and neatness in piecing them together. The shape of its dwelling, and the nature of the materials used, are often characteristic of the family, sometimes of the genus or species, to which a larva belongs. In the family *Phryganeidæ*, for example, the larvæ construct their cases with bits of leaves or twigs, cut into suitable lengths, and arranged side by side in such a manner as to form a spiral band passing many times around the case (see No. 7 in figure). The species of *Limnophilus* fashion their cases in various styles; the larvæ of *L. pellucidus* using entire leaves, so that the case may have a flattened form, wide in proportion to its depth. The cases made by *L. rhombicus* consist of bits of sticks or fibres placed transversely, with shells sometimes added; while those of *L. flavicornis* are often built almost entirely of the shells of different small mollusks, more especially those of *Planorbis*. What is still more remarkable about these cases is the fact that the caseworms do not necessarily select empty shells, but take those with living occupants as well, and fasten them all together around their backs. Grains of sand, of finer or coarser kind, are used by many larvæ in the construction of their cases; and the latter may be either cylindrical in form or slightly curved, or, as in the exotic genus *Helicopsyche*, they may, like snail shells, have a distinct spiral curvature. The grubs of other species arrange bits of sticks transversely in four different directions, using longer pieces as they progress, so that the complete case is four sided, with the sides gradually widening from one end to the other; and there is a type in which the four sides, instead of being straight, are carried round in a gentle spiral curve. The interior of each larval case is a tubular chamber, lined with silk, open at each end and about wide enough to enable the larva to turn inside. At the fore-end, which is generally a little wider, the head, thorax, and the six legs of the larva may be seen projecting; whereas the hinder end is usually closed by a silken partition pierced with holes. The body of the naked larva is made up of a number of segments, of which the first three — carrying the legs — are, like the head, hard and of a brownish color; while those that follow, about nine in number, are soft, white, and partly transparent. On the last segment are a pair of horny hooks, which enable the larva to grip tightly to its case. On the first abdominal segment three fleshy protuberances are often seen, — a longer one above and a shorter one on each side, — which appear to be used in enabling the larva to steady its body in the case, and to regulate its position with regard to the sides, so that the water necessary for breathing may pass freely in and out. The larva breathes by means of rows or tufts of soft white filaments — the tracheal gills — attached to the sides of all the abdominal segments except the first and last, and differing in arrangement in different species. Previously to entering the pupal stage, the larvæ of many species provide for their protection during that inactive and helpless period of their existence. They shut themselves up in their cases, some by closing the openings at each end with sieve-like plates of silk, which, while allowing free access to the water necessary for breathing, may serve to keep out their enemies; others by placing stones loosely over the openings, and so accomplishing the same purpose. There are a few larvæ, moreover, which, in their earlier days, make cases out of leaves, but add stones as they grow older, until just before pupation begins the case is entirely made of stones. Before the pupa is transformed into the perfect

insect, it extricates itself from its case, and leads an active life, swimming and running with agility. It then climbs up the stem of a plant to undergo its transformation. In some of the smaller species the pupa does not leave the water, but rises to the surface, and the fly emerges from the floating pupal skin.

Caddice flies are divided into seven families, arranged in two groups chiefly distinguished by the number of joints in the maxillary palpi of the male insect. In the first section — Inæquipalpia — the maxillary palpi of the male are composed of

LIFE HISTORY OF THE CADDICE FLY.
1. Larva; 2. Pupa; 3. Larva in its case; 4. Perfect insect.

two, three, or four joints, never five; thus differing from those of the female, in which the number of joints is always five. This section contains four families — the *Phryganeidæ*, *Limnophilidæ*, *Sericostomatidæ*, and *Hydroptilidæ;* the life history of a species of the typical genus (*Limnophilus*) being depicted in our illustration. The second section — Æquipalpa — is characterized by the fact that the maxillary palpi of the male are five jointed like those of the female; it includes the families *Leptoceridæ*, *Hydropsychidæ*, and *Rhyacophilidæ*.

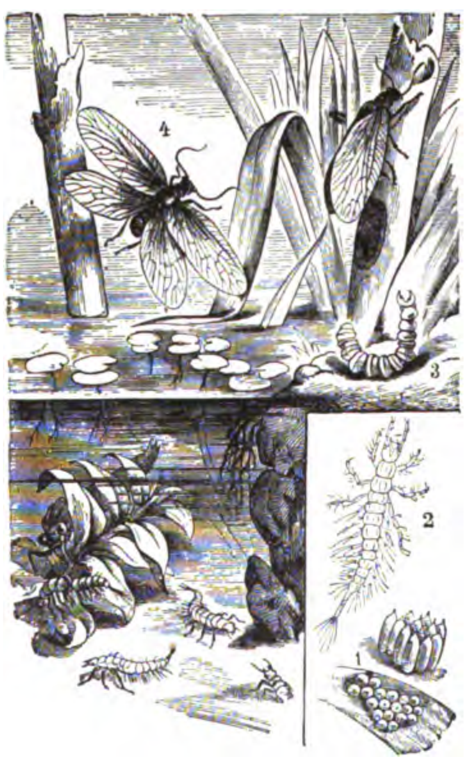
FLAT-WINGED GROUP — SUBORDER **Planipennia**

The members of this group are distinguished from the last by having both pairs of wings formed nearly alike, and usually provided with a closely reticulated system of nervures, with numerous transverse branches. The wings — which are incapable of being folded up — are for the most part naked; and, when at rest, are turned back in a slanting position against the sides of the body. The mouth organs are well developed, the mandibles in some cases attaining extraordinary proportions. The first family is that of the scorpion flies (*Panorpidæ*), which have a slender body, and the head turned downward and prolonged in the form of a beak, resulting from the elongation of the clypeus in front, and of the lower lip and maxillæ behind. The mandibles are rather short and narrow; the maxillæ, which are fused with the mentum, have five-jointed palpi; and the narrow lower lip is bifid at the extremity,

with three-jointed palpi. The antennæ are setiform, and inserted between the rather prominent eyes, and below the ocelli, which are usually distinct. The prothorax is short and collar-like; and the wings of these insects are less closely reticulated, and have fewer transverse nervures than those of the other groups. The common scorpion fly (*Panorpa communis*), which may be taken as the type of the

COMMON SCORPION FLY.
a. Female depositing her eggs; *b*. Male; *c*. Larva; *d*. Pupa.

family, is a shiny black insect about half an inch or more in length, with long, transparent, spotted wings, and a yellow beak and legs. The last three body segments of the male are narrow, and can be curved like a tail, and have a reddish color; the last carries a pair of pincer-like claws. It is from this circumstance that the insect has received its name, though it does not possess a sting like a scorpion.

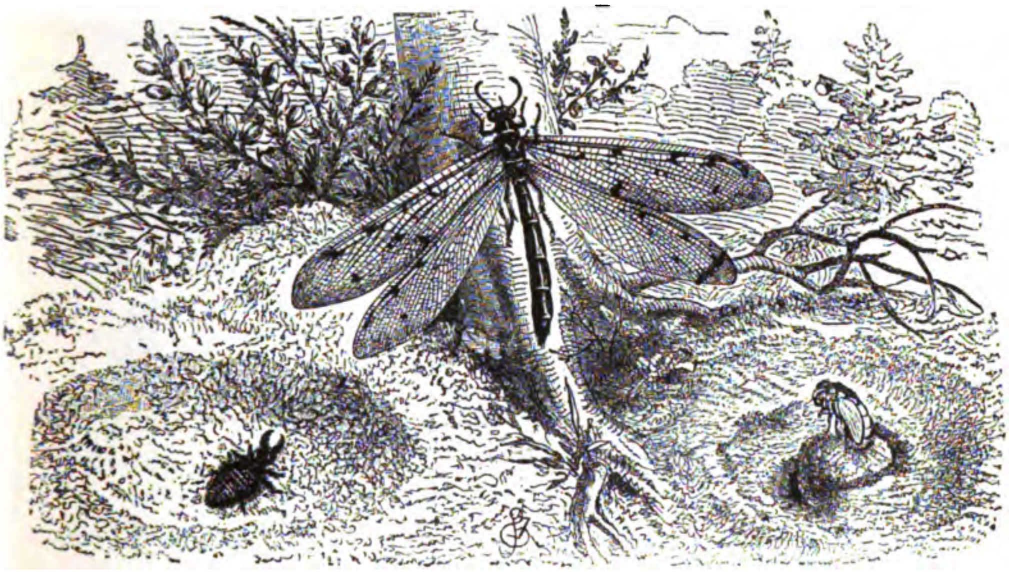


LIFE HISTORY OF THE ALDER FLY.
1. Eggs; 2. Larva; 3. Pupa; 4. Imago.

In the snake flies and alder flies (*Sialidæ*), forming the second family, the head is comparatively large, and often inclined in front, but never elongated in the form of a beak. The antennæ are bristle-like, and not so long as the body; the prothorax being strongly developed. The camel or snake flies (*Rhaphidia*) have the head long and narrow behind, and freely articulated with the long and narrow prothorax. The latter can also move freely at its articulation with the segment which follows; and this explains how the prothorax is raised, and the head bent forward in the characteristic attitude which these insects adopt when about to seize their prey, which consists usually of various small insects.

The alder fly, or May fly (*Sialis lutaria*), is at first sight rather like a caddice fly, but has a stouter body, and may be distinguished by its more completely developed mouth organs, as well as by the different structure of its wings. It emerges from the pupa about May or June. The winged in-

sects fly slowly and heavily, and are to be met with about trees and shrubs, or walls and palings, at no great distance from water. The female, which is somewhat larger than the male, lays her eggs in patches on a plant or other object in the vicinity of water. There may be several hundred eggs packed closely together in a single cluster; they stand upright, being cylindrical in form, with rounded ends, and each terminating above in a little white projection. The larvæ hatch in a few weeks, and then find their way into water, where they creep on the mud in search of the aquatic creatures on which they feed. When full grown, they are about an inch long, with a body tapering slightly toward the head, and, more gradually, toward the long and narrow tail. The head and three thoracic rings are horny, the rest of the body having a softer integument. The larva, which has strong legs and



b *a* *c*

LIFE HISTORY OF THE COMMON ANT-LION.

a. Imago; *b.* Larva; *c.* Pupa.

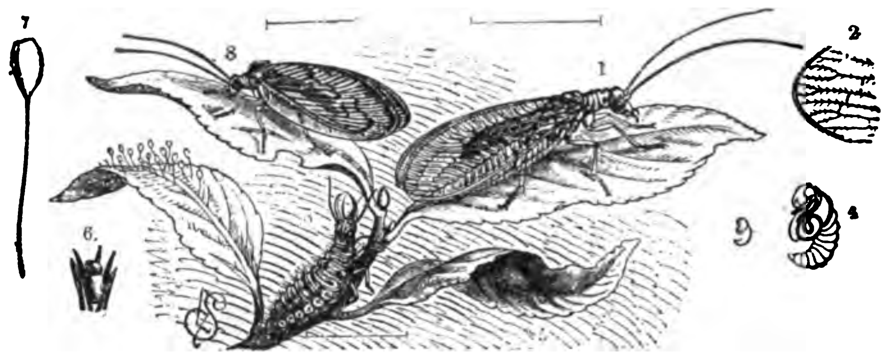
(Natural size.)

can walk well, breathes by means of tracheal gills, having the form of jointed appendages attached in pairs to the sides of the first seven abdominal segments. When the time for pupation arrives, generally about May or June, the larva leaves the water and seeks a place to bury itself in the earth. Having excavated a little cell, it throws off the larval skin and becomes a pupa, which has the legs and wings free from the body, but inclosed in special sheaths. After a few weeks longer it is transformed into the perfect insect.

The lace-winged flies, ant-lions, mantis flies, and some other families, have been associated in a third group of Planipennia, to which the name Megaloptera is given. In all, the wings are relatively large and closely reticulated; the prothorax being variable in size and form, and the joints of the tarsi not dilated. The mantis flies (*Mantispidæ*) take their name from the shape of the fore-legs, and their position

near the front end of the long prothorax; in which respect they resemble the mantis or praying insect. One species is common in South Europe. The larvæ live parasitically in the nests of spiders and tree wasps; and while they are at first free and active, they afterward become almost legless, like those of certain beetles. The allied family *Nemopteridæ* is mainly characteristic of the countries around the Mediterranean Sea. These insects have elongated and narrow, or almost linear, hind-wings, often widened out a little before the tip. The ant-lions (*Myrmeleontidæ*) may be recognized by their clubbed antennæ, and their long and closely reticulated wings, rounded off to an obtuse point at the extremity.

Of the European species the common ant-lion (*Myrmeleon formicarius*) is one of the best known. It lives in pine woods. The winged insect, which may be seen in July and September, rests during the day clinging to a plant, with its wings spread like a roof over the hind part of its body. At sunset it becomes active, and executes a slow flight in its search after food or a mate. The larva, to which the name ant-lion properly belongs, has the habit of making pitfalls to entrap its prey.



LACE-WINGED FLIES.

1. *Chrysopa vulgaris*; 2. The tip of its wing; 3. Larva; 4. Pupa; 5, 6, Cocoon; 7. Egg; 8. *Hemerobius hirtus*.

It is somewhat oval in the shape of its hind body, and has a narrow prothorax resembling a neck, and a rather big head, provided with a pair of long, curved, and sharply-pointed mandibles, each of which has three teeth on the inner side. Its body is arched up in the middle, and has wart-like protuberances, thickly covered with hairs, at the sides. When about to make a pit, it selects a dry and sandy spot, and begins by tracing out a circular furrow to mark its outer limit. Placing itself inside the circle, it buries its abdomen in the sand, and then proceeds with the work of excavation. With one of its fore-legs it shovels the sand on to its large flat head, to which it then gives a sudden jerk, and sends the sand out over the border. It repeats this process, walking backward and maintaining a spiral course all the while, until finally it reaches the centre of the cavity. Sometimes, however, instead of continuing to work altogether in one direction, it turns round and works the opposite way, thus giving relief to the leg which had previously been employed. And, as the sand is always taken from the inner side, it is the leg on that side that is always used as a shovel. The pit, when completed, is shaped like the mouth of a funnel, being wide above and gradually narrowed to the

bottom. Its size is adapted to the size of the larva, which when full grown makes a pit about two inches deep, and three inches wide at the top. Buried in the sand at the bottom, with only its antennæ and the tips of its mandibles projecting, the ant-lion waits until an ant or some other creature falls down the loose sides of the pit, when it is immediately seized with the pincer-like jaws, and retained until all the juices of its body have been sucked out, and nothing left but the dry and shriveled skin. The latter is cast outside the pit, and the larva again lies in wait. If by chance the victim should escape the first onslaught, and endeavor to scramble up the sides of the pit, its attempt is soon frustrated, for the ant-lion throws up sand with its head, causing the victim to tumble once more to the bottom.

The lace-winged flies (*Hemerobiidæ* and *Chrysopidæ*) are smaller and more delicate insects than the ant-lions, and have setiform antennæ. The golden-eyed fly (*Chrysopa vulgaris*), figured on p. 3130, may be taken as a typical species. It is slender, with long and richly-veined wings of a tender green color, as is also the body. Its antennæ are long and tapering, and its prominent eyes shine like hemispheres of gold. The larvæ of the lacewings are not unlike the ant-lion, although somewhat longer and narrower in proportion to the size of their bodies, and less hairy. Their mandibles, moreover, have no teeth on the inner side. In their carnivorous habits they resemble ant-lions, but instead of making pits and remaining stationary they rove about in search of their prey, which consists of the different kinds of green fly and plant lice.

Order ORTHOPTERA

This order being taken to include, not only the true Orthoptera, but various other groups formerly placed in the Neuroptera, and hence known as Pseudoneuroptera, it is necessary in defining the group to mention only such characteristics as are common to the whole of these insects. None of the members of the group undergo a distinct metamorphosis; the development from the larval to the adult condition taking place by a succession of changes, and the perfect insects being distinguishable from advanced larvæ by little more than the possession of complete wings. The wings are, however, in some cases confined to one sex, while in others they are altogether wanting in both sexes. The mouth organs, when not reduced to a functionless condition, are adapted to biting; the lower lip (labium) is nearly always divided in the middle at its free end, and each of the two halves often subdivided into a pair of lobes. On the floor of the mouth, concealed by the labium, there is, as a rule, a membranous or more or less horny structure, known as the tongue (lingua), or hypopharynx, which is free from the labium in its anterior part. Though poor in the number of species, as compared with some other orders, the Orthoptera contain many of the most interesting forms of insect life; some, like the leaf and stick insects, remarkable for their size and the variety of their protective disguises, others, as the white ants, for the wonderful development of their social habits. The dayflies are noted for the shortness of their lives, the dragon flies for their beauty; while many other forms are well known from some particular feature

or habit. In past epochs of the earth's history Orthoptera were well represented, their remains being found in rocks of various ages extending back to Paleozoic times. The oldest reputed insect is known by the impression of an orthopterous wing (*Palæoblattina*), from the Silurian sandstone of Calvados in France. There is some doubt as to which group of the order the insect belonged, and even as to whether the impression owed its origin to an insect at all. However this may be, traces of undoubted Orthoptera, as well as of Neuroptera, are met with in rocks of Devonian and Carboniferous ages. The Orthoptera of the latter period included numerous cockroaches (*Blattidæ*), together with stick insects, ephemerids, and dragon flies, some of which greatly exceed in size any existing form. One of the dragon flies (*Meganeura monyi*), was thirteen inches in the length of its body, and each of its wings was quite a foot long.

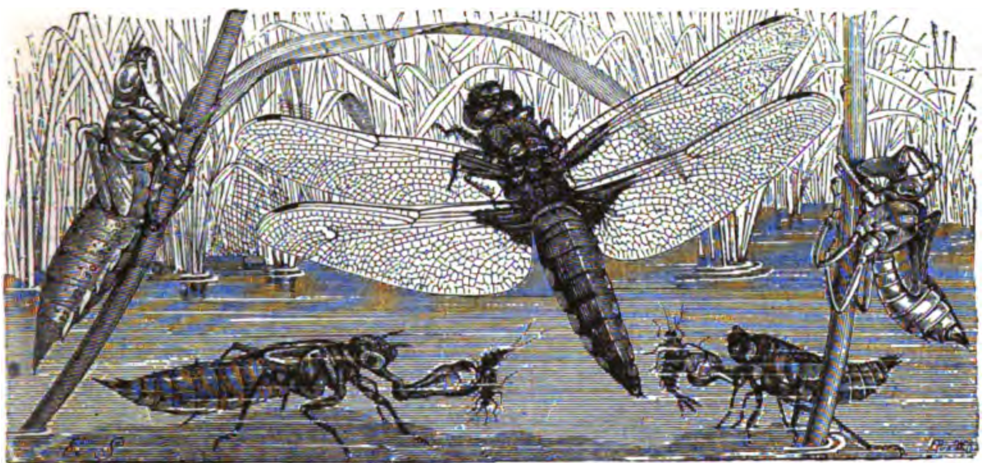
The Pseudoneuroptera are distinguished from the Neuroptera by the absence of a pupal stage. While agreeing in this respect with the typical Orthoptera, these insects differ by certain characteristics not generally considered of the first importance. Both pairs of wings in this group are thin and membranous, resembling one another in structure, and the hind-wings do not fold up; whereas in the true Orthoptera the fore-wings are usually thicker and harder than the hind-wings, and the latter are capable of being folded like a fan.

Dragon Flies

The first group is that of the dragon flies (Odonata), the general appearance of which is too well known to need description. All have a large head, the sides of which are covered almost entirely by the two big, glassy-looking, compound eyes, while on its crown are two or three small simple ocelli. Each of the short and bristle-like antennæ has a stouter basal portion by which it is inserted on the forehead. The mouth faces downward, and has a large semicircular lip (labrum) in front; the jaws being strong, horny, and well provided with teeth. The maxillæ are without palpi, but their narrow and palp-like outer lobe is often regarded as the real palp. Succeeding the jaws behind is the lower lip (labium), which at its free end is usually slightly cleft in the middle, while its palpi take the form of two dilated and often two-jointed lateral lobes; these lobes sometimes overlapping one another in front to hide the free end of the lip. The thick and cylindrical thorax is followed by a long slender abdomen, which usually carries at the end two leaf-like or pincer-like appendages. When looked at from the side, the two hinder segments of the thorax appear oblique, with the wings set rather far back above, and the legs pushed forward below. The wings are long, transparent, and traversed by a rich network of veins. The legs are often spiny, and their tarsi are always three jointed. The position of the accessory organs of the male on the under side of the second abdominal ring is a feature distinguishing dragon flies from other insects.

The female dragon fly deposits her eggs in such a position that the larvæ, when hatched, find themselves either in their natural element, the water, or very close to it. In some species the female, accompanied by the male, goes under the water to lay her eggs; others drop them into the water; while in many species the female makes incisions in some aquatic plant and there deposits her eggs. The larvæ are even more fiercely carnivorous than the adult, and are distinguished from all other

aquatic larvæ by the possession of a peculiar structure fixed under the head, known as the mask. In their mode of respiration dragon fly larvæ are also peculiar, some being provided with external tracheal gills — in the form of three leaflets placed near the tail end — which serve to assist in locomotion, while others breathe by means of gills of an exceptional character. The latter are situated in the hinder part of the intestine and consist of six longitudinal bands in its walls, crossed by several transverse folds, supplied with numerous fine branches from the tracheal trunks. Water can be sucked in at the opening, guarded by five valves at the hind end of the body, and when it becomes vitiated can be squirted out again either gently or with considerable force. When it is suddenly and violently expelled, it serves to propel the insect forward at a rapid rate. The larvæ live about ten or twelve months, during which time they undergo several molts; rudiments of wings appearing some time before the final transformation. When this is



LIFE HISTORY OF DRAGON FLIES.

1. Larval skin of a dragon fly; 2. Larva with its mask exserted; 3. *Libellula depressa*; 4. Advanced larva of a libellula; 5. The same about to undergo its final transformation.

about to take place, the larva leaves the water by climbing the stem of a plant, or to some other dry spot. As the time approaches, its eyes, which were before dull and opaque, become bright and transparent. Its skin dries up, and soon begins to crack along the middle of the thorax; the thorax appears through the cleft, and swelling up causes it to extend; the head is next disengaged, and the legs are then drawn out of their sheath. The insect now throws its head farther and farther back, and by this means gradually frees the hinder part of its body, with the exception of the last few segments which still remain inclosed in the larval skin. After a while, it suddenly bends its body forward, grasps the sides of the sheath with its legs, and, doubling up its abdomen, finally extricates the rest of its body.

Dragon flies are divided into three families, of which the first two have more in common with one another than with the third. The *Libellulidæ* are distinguished by their comparatively stout bodies; by the size of their eyes, which cover almost

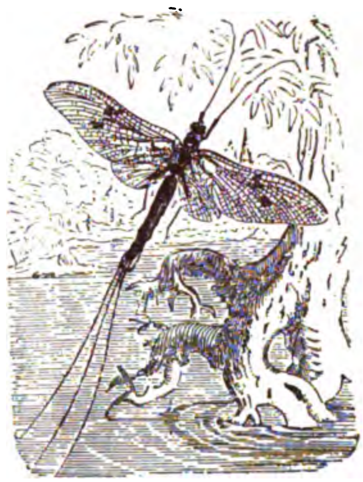
all the sides of the head, and very nearly meet on its crown; and by the structure of their lower lip, in which the median terminal piece is short and slightly divided at the end, while the very broad palps spread out and overlap it in front. The last characteristic is useful in distinguishing the *Libellulidæ* from the next family, which in many respects they resemble. Their larvæ breathe by means of internal gills, and have a mask which is hollowed out on the inner side, and somewhat resembles a helmet. Members of this family are found in most parts of the world, and about twenty species occur in Europe. The *Æschnidæ* have eyes even larger than those of the *Libellulidæ*. The end piece (ligula) of their lower lip is not divided in front, and not exceeded in length by the palpi; while each of the latter is armed with a strong tooth or spine. The abdomen is long, narrow, and cylindrical. Their larvæ are more elongate, and have bigger eyes than those of the last family. The flat mask has the palpi narrow, and armed with a movable hook at the tip. Like the larvæ of the *Libellulidæ* they are provided with intestinal gills. Some of the largest dragon flies belong to this family.

The *Agrionidæ* form a family of slender-bodied dragon flies, which have both pairs of wings shaped nearly alike. They are further distinguished from the other two families by the shape of the head, the smaller size of the eyes, and the structure of the lower lip. The head has a projection at each side, at the end of which is placed one of the two hemispherical eyes; and on the wide space, lying between the compound eyes, there are three ocelli arranged in a triangle. The lower lip consists at its free end of three parts of nearly equal length; the median piece (ligula) being notched in the middle, while the two palpi consist of two joints, of which the first is large and terminates in an inwardly curved spine, whereas the second is small and articulated with the first, outside the base of its spine. The larvæ may be known by the three leaf-like tracheal gills at the end of their body, which are wanting or inconspicuous in those of the other families. This family contains many of the most brilliantly and variously colored dragon flies; the sexes of the same species often differing in coloration. Some of the exotic species attain a great length, but this is brought about by the elongation of their slender abdomen without a corresponding increase in the proportions of the other parts of the body.

May Flies

The dayflies, or May flies (*Ephemeridæ*), constituting the second group of the Pseudoneuroptera, are comprised in a single family. They have soft and fragile bodies, with a long ten-jointed abdomen, bearing at the extremity two or three long, bristle-like, and many-jointed tails. The hind-wings are sometimes wanting, and, when present, are always much smaller than the front pair, the latter being usually three sided, with the corners rounded off. Three ocelli, in addition to the two large compound eyes, are borne upon the head; and the antennæ are short, and composed of two stout basal joints, followed by a slender, many-jointed bristle. In the adult the mouth organs are never well developed, but remain small and soft. The jaws have no function to perform, as the perfect insects do not eat, but devote entirely to other pursuits the short span of life remaining to them. The common notion that the life of the May flies in the winged state lasts but a single day is sometimes, but not generally, true, many being able to live several days, provided the atmosphere be not too dry. There are some.

however, which do not live for even the proverbial day, but emerge one evening, only to perish before the sun again appears. There is less truth in the supposition that these insects appear only in May; May flies of one species or another being seen on fine days throughout the summer and autumn. They are to be found in the neighborhood of rivers and lakes, some flying only by night, and others during the cooler hours of sunlight, or on favorable evenings until a little after sunset. During the heat of the day they seek repose, with their wings raised vertically. If the day be cold and raw, they seldom fly, but remain under shelter. In fine weather, however, they may sometimes be seen assembled together in swarms about sundown, and engaged in their pastimes, which are continued till some time after sunset. The peculiar up-and-down movement, which marks the flight of some species, has been often observed; and the mazy dance of the May flies has been described by more than one author. In these dancing assemblies the male insects always greatly outnumber those of the other sex. The larvæ of the *Ephemeridæ* live in water; a few kinds are carnivorous, but most feed upon the minute vegetation scattered through the mud or covering stones, and the larger aquatic plants. Many remain concealed in the banks or under stones, while others rove among water weeds, and swim with celerity. The larvæ of some genera are found only in large rivers. The eggs are, in some cases, deposited at the surface of the water, and then sink to the bottom; but in others the female creeps into the water to lay her eggs in patches on the under side of stones. The eggs are exceedingly numerous, and vary in shape according to the genus. The larvæ cast their skin several times; they are at first without special organs of respiration, but when they are about eight or ten days old tracheal gills begin to appear and ultimately develop into forms, which vary somewhat in the different genera. The gills are attached in pairs to the sides of some, or all, of the first seven segments of the abdomen, in some species standing out straight from the sides, and in others turned over the back. The mouth organs of the larvæ are better developed than in the

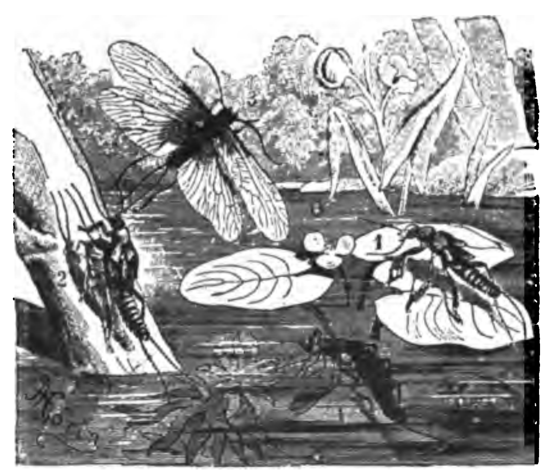


MALE OF COMMON MAY FLY, *Ephemera vulgata.* (Natural size.)

A MAY FLY AT ITS FINAL MOLT, WITH THE IMAGO ESCAPING FROM THE SKIN OF THE SUBIMAGO. THE LARVA BELOW.

adult, the mandibles being nearly always strong and toothed, and sometimes giving off a tusk-like process in front of the head. At their transformation most May flies do not change directly from the larval form into the imago, but first pass through a stage, known as the subimago, in which they have their wings expanded, and breathe through the spiracles like the perfect insect. In this form they are distinguished by the dullness of their integument, the shortness of the fore-legs and tail bristles, and the less prominent and duller eyes. The subimago emerges from the larval skin at the surface of the water, and, after standing awhile upon the water, flies to a more convenient resting place. At the next molt, which soon follows, the perfect insect makes its appearance. The emergence of May flies takes place at different periods during summer and autumn, and that of any one species may last for several days in succession. At this time they sometimes appear in countless numbers, as thick in the air as snow-flakes, and at the end of the brief existence leave their dead bodies to cover the ground, or float in masses down the stream.

Nearly fifty species of *Ephemeridæ* are found in the British Islands. Two of the commonest (*Ephemera vulgata* and *E. danica*) are, in the subimago stage, known to anglers as "green drake" and "gray drake." They are four-winged species, with a body from one-half to three-quarters of an inch in length, and furnished at the end with three very long tails. The fore-legs are extremely long, especially in the males, which sex is distinguished also by the much larger size of its eyes. The larvæ of *E. vulgata* burrow in the mud, or hide under stones, in ponds and sluggish streams. They have rather long antennæ, and the tusks of their mandibles project a good way, and cross one another in front of the head. They have six pairs of tracheal gills, which are turned up over the back, each gill consisting of two narrow blades, united at the base, and fringed with hairs along each side. The final transformations of the larvæ occur about the end of May, or early in June, at which time, on a fine evening, the winged insects may sometimes be seen in hundreds, dancing in the air.



COMMON STONE FLY (*Perla bicaudata*).
1. Larva; 2. The fly escaping from the larval skin; 3. The perfect insect.

Stone Flies The stone flies (*Perlidæ*), forming the last group of Pseudoneuroptera with aquatic larvæ, are narrow, elongated insects of a flattened form, with a good-sized head, rather long, many-jointed antennæ, and four not very closely reticulated wings, which shut horizontally over the body when at rest. The abdomen usually carries two long, multiarticulated styles at the extremity. The mouth organs are weakly developed in the adult insects; the mandibles and maxillæ are membranous; the maxillary palpi long, with slender

terminal joints, and the labial palpi three jointed. The thorax is square or oblong, with its three segments almost equally developed. The tarsi are three jointed, and have their claws separated by a bilobed pad. The species of this family are not numerous, though some are almost world wide in their distribution. The adults appear about the same time as dragon flies and alder flies, and frequent nearly the same places. Though they have large enough wings, they fly heavily, and not for any considerable distance at a stretch, and are generally most active in the evening. The female fastens her eggs loosely together, and drops them in masses as she flies over water. The larvæ are mostly found in rapid streams, where they keep under stones, or among broken pieces of wood, and live by preying actively upon the weaker creatures inhabiting the same waters. They have strongly-developed jaws, and rather long palpi. They breathe by means of tracheal gills, in the form of tufts of filaments, attached to the bases of the legs and the sides of the integument which joins the three thoracic and the first abdominal rings to one another. The two filamentous tails may have a pair of tracheal tufts at their base. In later stages of their life the larvæ exhibit rudiments of wings. When the time for its transformation arrives, the full-grown larvæ, or nymph, leaves the water by climbing the stem of a plant, or crawling some distance up the bank until it finds a dry stone on which to stand, when the emergence of the imago takes place in the usual way, preceded first by a splitting of the larval skin along the middle of the thorax. When the insect is free, its wings dry rapidly, and it is soon ready to fly.

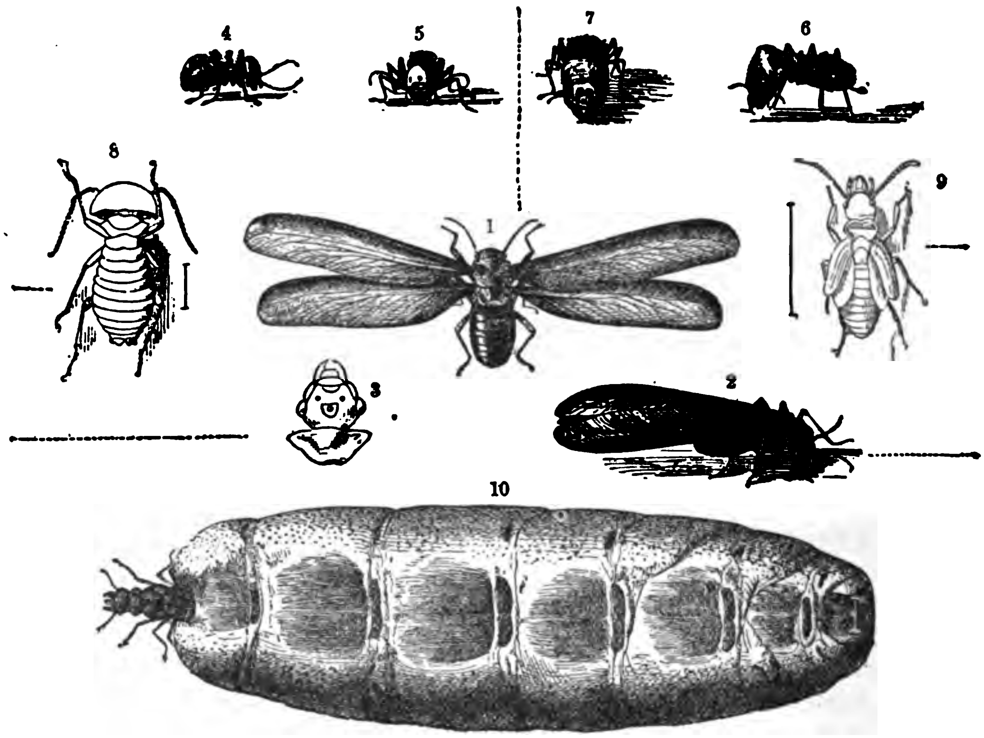
A fact of importance, first noticed in the *Perlidæ*, though it also occurs in some other groups, is that the tracheal gills are retained by the perfect insects, where they are attached in the same places as in the larva, but much reduced in size, and probably, in most cases, functionless. As an example of the *Perlidæ*, one of the best-known British species, *Perla bicaudata*, is figured on the opposite page.

Termites or White Ants

The termites or white ants (*Termitidæ*) differ considerably in one respect from all the other groups of Pseudoneuroptera. They live in societies which are of a highly organized and complex nature and most resemble those met with among insects of the highest type, such as bees and ants. This is, however, the only direction in which the termites diverge to any extent from the rest of the Orthoptera; for, like all these, they pass from the larval to the adult state by a series of gradual changes; while, in the structure of their bodies, they show an affinity with some of the lowest groups of the order. In the termites the head is free and distinct, with the antennæ composed of a number of small bead-like joints, and rather short. The perfect insects have compound eyes, and, as a rule, two ocelli; but the wingless individuals are generally without eyes of any kind. The mouth parts, which are constructed on a clearly orthopterous plan, are not very unlike those of a cockroach, and consist of a distinct upper lip (labrum), two strong horny mandibles, a pair of two-lobed maxillæ with five-jointed palpi, and a lower lip (labium), divided at the end into four lobes, and bearing three-jointed palpi. In the thorax the first segment is well developed, and its dorsal plate, or pronotum, is rather broad and flat; the other two segments being less strongly developed, though in the winged insects attaining a fair size. Both pairs of wings are much alike; they are long, narrow, not very closely veined, each wing

being marked by a transverse suture at a short distance from the base; and in a state of rest they are laid flat over the back. The legs are slender, and well fitted for running, and their tarsi are four jointed. The abdomen has a slightly elongated or oval form, and carries two very short appendages—the cerci—near its extremity.

The common habitation of a society of white ants is known as a nest; and in each nest, which is divided into a number of cells or chambers communicating with one another, there may be found several different kinds of individuals in addition to the larvæ. Some are provided with wings, or with the rudiments thereof, and are



WHITE ANTS AND THEIR DEVELOPMENT.

1. Male of *Termes dirus*; 2. The same, seen from the side; 3. The head (enlarged); 4. Worker; 5. The same, front view; 6, 7. Soldier, side and front view; 8. Worker (much enlarged); 9. Nymph; 10. Queen.

distinguished also by having eyes. These are the sexually developed males and females, which are capable of reproducing their kind; though this function is, as a rule, carried on by a single couple in each nest. The king and queen—as this couple are named—are lodged in a large cell near the middle of the nest, and may be recognized by their large size, and the fact that they retain but small stumps of the wings which they once possessed. The royal cell is larger than the others, and has thicker walls; while the passages leading into it are too small to afford the occupants a means of escape, though large enough to admit the workers, which come and go, some to bring food to the royal pair, others to carry away the eggs laid by the queen. At this time the abdomen of the queen, owing to the number of eggs it

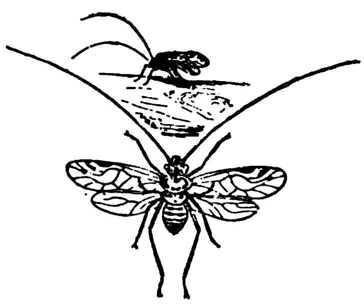
contains, is swollen to an enormous size. "She lies there," writes Drummond, in reference to one of the African species, "a large, loathsome, cylindrical package, two or three inches long, in shape like a sausage, and as white as a bolster." Her eggs are discharged at a rapid rate, amounting in a single day to several thousands, and the process is continued with the same activity for months in succession. Both workers and soldiers are wingless members of the community, and, in the majority of species, have no eyes. The workers have small and rounded heads, with short mandibles, and well-developed maxillæ and palpi; whereas the soldiers are easily recognized by their big, square, or oblong heads, and long mandibles. The workers are the most numerous class, and have many duties to perform in the way of building tunneling, and providing food for the young larvæ and for the king and queen. The soldiers look after the protection of the workers, and act generally in defense of the community. In one genus there are no true mandibulate soldiers; but there is instead a class of individuals, known as "nasuti," from the fact that their pear-shaped heads are prolonged in front in the form of a beak. The exact part which the nasuti play is not yet clearly known; but, like the soldiers of other species, these individuals appear at the first sign of danger, and shake their head and palpi in a most menacing way. The eggs of the queen termite are, as mentioned, carried away by bodies of workers, and placed in special chambers or nurseries. When the young larvæ are hatched, they are at first indistinguishable from one another, and are little blind creatures, with soft and pale integument; and it is only after the first or second molt, that they begin to show those differences which subsequently distinguish the larvæ of the various classes. They are fed with a special kind of food, consisting of comminuted dead wood, mixed with saliva, which certain of the workers prepare for them. By varying the quantity and quality of the food supplied, the termites appear able to arrest or deviate the development of larvæ that would, in the ordinary course, become perfect insects or, in other words, they can produce workers and soldiers from larvæ which, if fed upon a different diet, might develop into winged insects fitted to become kings and queens. And it has been shown that neither the soldiers nor the workers of the termites belong to one particular sex only, as is the case with the neuters of bees and ants, but that individuals of both sexes, in an imperfect sexual condition are comprised in each class. The winged insects into which many of the larvæ develop are most abundant at certain periods of the year, especially after rains; they do not remain long in the nest, but, after a few days at the most, make their way out, or are led out by the workers, and shortly afterward take flight. They may often be seen flying in swarms, and at night sometimes enter houses, being attracted by the light. Many are devoured by birds, which seize them as they leave the nest. When they have finished their flight, and alight on the ground, they shed their wings, which easily snap off at the line of suture near the base. If a couple, chancing to be near a termite burrow, are found by some workers, they are brought in, a royal cell is prepared for them, and, as king and queen, they become the parents of a new colony. Some larvæ develop into individuals, which, although fitted to perform the functions of perfect insects, never possess complete wings, but are provided at most with wing pads, or rudiments of wings. These individuals, which somewhat

resemble the nymphs of the perfect insects, are known as substitution kings and queens, and take the place of true royal couples, when from any cause the latter are not to be found.

The food of white ants consists ordinarily of decaying wood, or similar vegteable matter, which, when it has passed in a half-digested state through their bodies, is eaten again. These insects have also the habit of devouring their dead, which makes it possible to destroy a whole colony by placing a little arsenic or mercuric chloride in their food; for the few that die through first partaking of the poison are eaten by others, which in their turn are also devoured, and so the poison is spread through the entire population. About two hundred species of termites have been described; and these inhabit chiefly the tropical and subtropical parts of the world, although two small species are found in the south of Europe. Some species live in the hollows they have eaten out in the interior of the trunks and branches of trees, or in timber. They line the galleries they make, which are often so close together as to be separated only by a thin wall, the wood in the interior being almost all eaten away. A few make openings to the exterior, and form nests around the branches of trees; these nests being sometimes as large as a sugar barrel, though the size varies considerably. The nests of most species are usually placed entirely below the level of the ground, and often lie beneath mounds of earth raised above the surface. Some of the larger African species, such as *Termes bellicosus*, build mounds of earth, frequently reaching a height of twelve or fourteen feet. These mounds, which may stand singly, or in groups of varying size, are divided inside into chambers and galleries communicating with one another and with the nests and galleries underground. The nests of this kind, which consist almost entirely of clay, become in time quite hard and solid, and are much more durable than those which are composed of particles of dead wood pasted together with a sticky saliva or with excrementitious matter. From the central nests termites construct underground galleries or tunnels leading in different directions, and sometimes reaching hundreds of feet in length. When it is necessary for the workers to go above ground in search of food, they protect themselves by building covered ways leading to the object they desire. Their tunnels sometimes lead to the interior of houses, and when once termites gain admittance in this way there is scarcely any limit to the mischief which may result from their operations. The wooden pillars that support the roof, the woodwork of the roof itself, and even articles of furniture, may be destroyed before the inhabitants become aware of what is taking place. For in tunneling through wood termites take care to leave the outer shell intact; and what appears on the outside to be a solid piece of wood may consist in the interior of nothing but a series of galleries lined with white-ant mortar. These insects easily make their way into wooden boxes, and quickly destroy the books, papers, clothing, or whatever else they may contain. The rapidity with which they work is remarkable, and in a single night they have been known to burrow up through the leg of a table, then across the table, stopping on the way to devour the articles lying on it, and down through another leg into the floor again. Forest trees, also, are often ruined by the action of termites, which. in order to get at the dead branches will sometimes bore their way up through the trunk, and thus bring about its premature decay.

Book Lice The book lice and the other insects classed with them in the family *Psocidæ* form another small group of Pseudoneuroptera. They are mostly very small insects, with a proportionately big head, swollen in front, and carrying prominent eyes, three ocelli, and bristle-like antennæ. Their mandibles are horny at the tip, but the other parts of the mouth are usually soft and membranous; the maxillæ being bilobed, with four-jointed palpi, and the palps of the bifid labium rudimentary. The middle segment of the thorax is the largest, and the prothorax is usually very short and narrow. The wings, which are wanting in some species, are slanting in repose, like the sides of a roof, and cover over the abdomen; they are of an almost glassy transparency, and have, as a rule, an open system of neuration. The tarsi are composed of two or three joints. Most species of *Psocidæ* live in the open air, and feed on fungi, lichens, and the fragments of other plants; the largest European species (*Psocus lineatus*) being scarcely more than a quarter of an inch long.

Bird Lice The Mallophaga, commonly known as bird lice, are small wingless insects, resembling ordinary lice to some extent, but differing from them in many characters, and especially in the structure of the mouth, which is fitted for taking food by biting instead of sucking. They form a distinct group, now generally placed in the Pseudoneuroptera, though some entomologists assign it a position near the Pediculina or true lice. The bird lice are flat-bodied insects, with a broad head, varying a good deal in form, and a thorax which usually appears to consist of only two segments. Their antennæ are short and composed of three, four, or five joints; and their eyes, when present, are simple. The mandibles appear as short hooks, sometimes toothed on the inner side; the maxillæ are short and said to be always palpless; while the lower lip is distinct and often bears palpi. The legs are short and stout, and have two-jointed tarsi, each of which carries at the end either one or two claws. As bird lice are found on mammals as well as on birds, their name is to some extent misleading.



Psocus lineatus (enlarged three times).

True Orthoptera (*Orthoptera Genuina*)

The insects of this suborder differ chiefly from those of the last group in the characteristics of their wings, in which the two pairs are not formed alike. The fore-wings, which are usually stiff and tough, and in some cases horny, serve as wing covers, and are generally spoken of as elytra; whereas, the hind-pair are membranous, and capable of being folded longitudinally, or both longitudinally and transversely. The division of the ligula, or terminal piece, of the lower lip into two or four lobes, is usually more complete than in the Pseudoneuroptera. It is usual to divide the true Orthoptera into two series or tribes — the Saltatoria, with

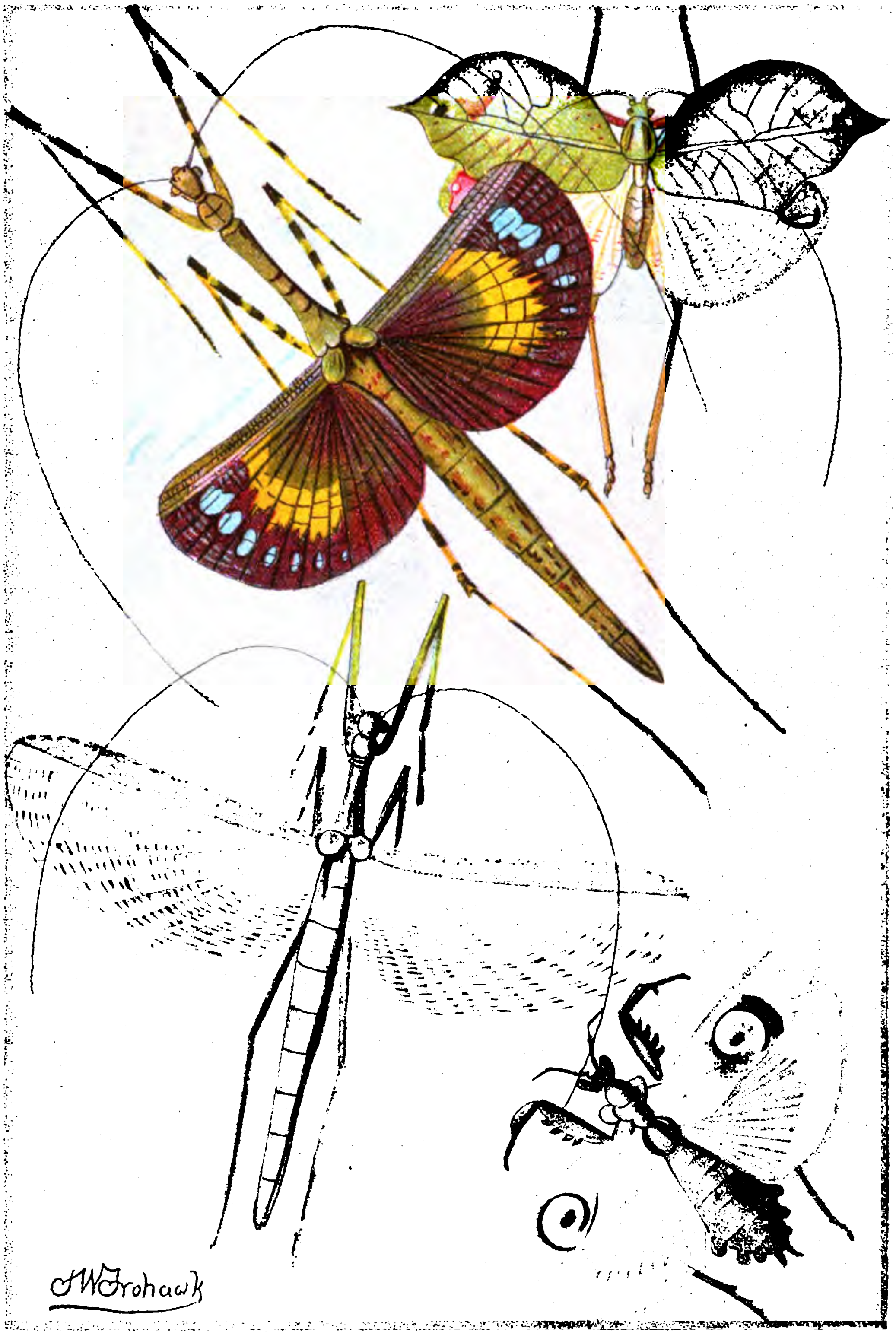
strongly-developed hind-legs, adapted for leaping, and the Cursoria, in which the hind-legs are not thus developed, but are better fitted for use in running and walking. The saltatoria, or jumpers, are sometimes spoken of as the Musical Orthoptera, since nearly all these insects, such as crickets, grasshoppers and locusts, are noted for the loud chirping sounds which the males produce. The females are supposed to be attracted by the chirping of the males; they seldom emit any sound themselves, and when they do it is generally of a very feeble character. It is probable that most insects can hear, but by what means they do so is, in the majority of cases, to a great extent a matter of conjecture. The Saltatorial Orthoptera are, however, remarkable in possessing very definite organs of hearing, which, though occupying a different position, are functionally comparable to the ears of higher animals.

Crickets

The crickets (*Gryllidæ*) which form the first family of the suborder, have a somewhat rounded head, supporting long whip-like antennæ. Their mandibles are strong and toothed; the inner lobe of the maxillæ being devoid

1-4. FIELD CRICKET (*Gryllus campestris*)—(1) male, (2) female, (3 and 4) young and old larvæ; 5. MALE OF THE HOUSE CRICKET (*Gryllus domesticus*).

of teeth, and the outer one long and slender. The fore-wings, or elytra, do not differ from one another in structure, and, and when at rest, are closely applied to the somewhat thick and massive hind-body. The hind-wings are folded many times, and may generally be seen projecting beyond the tips of the elytra. The hind-legs are generally used in jumping, while the other two pairs are better adapted for walking, although in the mole crickets the fore-legs are thickened and otherwise modified for use in burrowing. The tarsi of all the legs are composed of either two or three joints. The abdomen bears near the tip two flexible, velvety appendages, which are sometimes very long; and in the females it usually carries also a long exserted ovipositor. The chirping of crickets is produced by rubbing the base of one elytron over the other; in which respect these insects differ from most grasshoppers and locusts, and resemble only those grasshoppers with long antennæ, which belong to the family *Locustidæ*. They resemble the latter also in having their organs of hearing placed on the fore-legs. These organs are lodged in the upper part of the tibiæ, a little below their articulation with the femora, and consist externally of two small depressions or pits on opposite sides of each tibia,



ORTHOPTERA.

with a thin membrane stretched across the bottom of each depression. Inside the leg a tracheal vessel widens out between the two tympanic membranes, to form a vesicular expansion, on which are distributed the end cells and rods of a nerve which comes from the first thoracic ganglion. Crickets are found all over the world, but only four species are British. Of these one (*Nemobius sylvestris*) may be recognized by its small size, being little more than a third of an inch long. It is usually found among the dead leaves in woods, and appears to be restricted in its range to the southern counties. The field cricket (*Gryllus campestris*), which sometimes measures an inch in length, is generally of a black color, and lives in dry fields, where it is often heard though seldom seen on account of its retiring habits. The house cricket (*G. domesticus*) has a reddish brown color, and is somewhat smaller than the field cricket. It has well-developed wings, and the female has a long ovipositor. The mole crickets, of which there is one British species (*Gryllotalpa vulgaris*), have such a peculiar structure that they are easily distinguished from all

MOLE CRICKET, WITH EGGS AND LARVÆ.
(Slightly enlarged.)

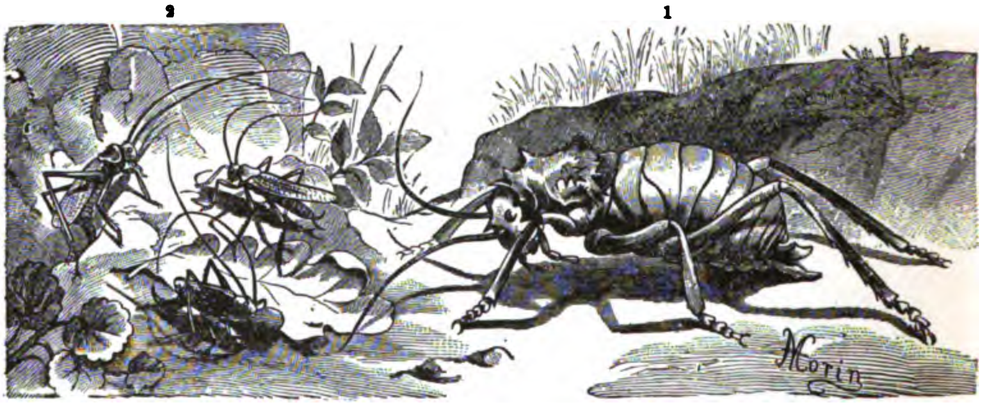
other insects. They have a long, smooth, shiny prothorax; rather short, close fitting elytra; and under wings which, when rolled up, look like a tail curving down over the tip of the abdomen. The abdomen itself carries two long flexible tails, which are said to be used like antennæ, when the insect runs backward. It is, however, by the extraordinary shape of the fore-legs that these insects may be most easily recognized. These limbs are thicker, but shorter than the hind-legs; they have very short tibiæ, each ending below in four strong claws spread out like the fingers of a hand.

Long-Horned Grass-hoppers

Although named *Locustidæ*, this family does not comprise the locusts, but includes only those grasshoppers in which the antennæ are long and tapering, and the tarsi are four jointed; while the female is provided with a long ovipositor. Besides these characteristics, there are some others which help to distinguish the *Locustidæ* from the members of the next family. In the present group the organs of hearing are placed, as in the crickets,

in the tibiæ of the fore-legs; and the chirping of the male is produced by the friction of the wing covers over one another. The wing covers, instead of being both alike, as in crickets, exhibit a certain amount of difference in the arrangement of the veins and structure of the membrane in their basal part. Taking the male of the large British green grasshopper as an example, it will be seen that on the portion of the right elytron which folds horizontally over the trunk, there is near the base a somewhat irregularly circular area, which has a glistening appearance, like a piece of talc. This area is bordered by a strong prominent vein. In a corresponding position on the left elytron, which, when closed, overlaps the right, there are also some thick transverse veins, but the cells inclosed by these veins have a similar texture to the rest of the membrane. When the insect rubs its left elytron rapidly over the right the veins projecting on the under side scrape on the margin of the mirror, and set the latter in vibration, thus giving rise to the well-known sound. The chirping of the *Locustidæ* is generally louder and more prolonged than in the other grasshoppers. In certain North-American species known as katydids, the song

2 1



1. FEMALE OF *Hetrodes spinulosus;* 2. MALE AND FEMALE OF *Meconema varium.*
(All natural size.)

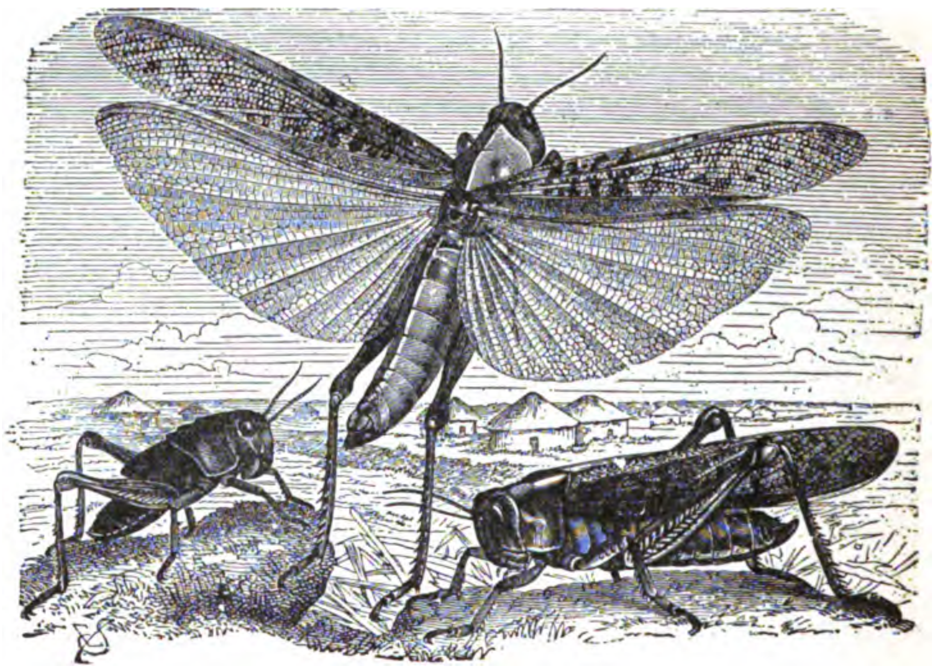
seems to consist of these words repeated again and again, with a slight variation. The life history of the *Locustidæ*, so far as it is known, does not differ in any essential respect from that of the *Acridiidæ*. It is probable that in most cases the female uses her long ovipositor to lay her eggs at some depth in the ground, though in some species the female is known to deposit her eggs on plants. These grasshoppers are less herbivorous in their habits than those belonging to the next family; many of them are, in fact, believed to be more carnivorous than herbivorous in their tastes. The *Locustidæ* are most numerous in species in America and Asia; there being not many more than two hundred species in Europe, of which about ten are British. In the large green grasshopper (*Locusta viridissima*), which is nearly an inch and a half long, and is easily distinguished by its size from all the other British species, the male makes a harsh and strident noise, by which attention is attracted, when otherwise, owing to its green color, it might altogether escape notice. Green is the prevailing tint in very many species of this family. In some species the elytra have the most exquisite resemblance in color and

venation to green leaves; while in others they look more like withered leaves. Nowhere is this style of protective coloration better displayed than in the exotic genera *Cycloptera* and *Pterochroza*, one of the species of which is figured in the colored plate. The shape, color, and venation of the wings are not only exactly like those of leaves, but there may be seen, here and there, little glistening, transparent patches of cuticle, which reveal, as it were, the work of an insect grub. In others, fungi seem to grow on the leaves, and leave their mark in the discolored patches which may be seen scattered about. Among the species of the family remarkable in other respects we have space to mention only a few. In the genus *Hetrodes* the adult insects of both sexes are without wings; the prothorax is very large, and is armed above with a number of spines. An idea of the general appearance of the adult insect may be gathered from the figure of *Hetrodes spinulosus*. This species is found in Arabia and Syria. For the sake of contrast the male and female of a small British grasshopper (*Meconema varium*) are figured beside it. The latter is winged in both sexes; it is found in oak trees, and belongs to a subfamily which is peculiar from the fact that the elytra of the male have no stridulating organs.

Locust Tribe

The locusts and short-horned grasshoppers (*Acridiidæ*) are distinguished by easily recognized characteristics from the other two families of the suborder. The antennæ are short, seldom attaining more than half the length of the body, the tarsi are three jointed, and the female always has a very short ovipositor. They differ also in the position of the auditory organs, and in the mode by which the males produce the chirping. In these insects the organs of hearing appear externally as two pits, somewhat crescentic or semilunar in shape, placed one on each side of the first abdominal segment, immediately behind the thorax. At the bottom of each pit there is a tense membrane, which on its inner side is brought into relation with the terminal rods and fibres of a nerve which arises from the last thoracic ganglion. It was thought that these pits were in some way concerned in the production of sound, but it is evident from their structure that this is not the case, while they really seem capable of serving no other function than that of ears. Moreover, it is now known that the chirping of these insects is produced by rubbing the hind-legs up and down against some of the projecting nervures in the sides of the closed elytra. When the insect is stridulating it keeps the tibia of the leg folded up against the femur. In some species the sound is heard at both the upward and downward stroke of the legs, in others at the downward stroke only. The sound varies in intensity in different species, and for this reason some of the commoner species may be recognized even before they are seen. In most of these insects the front of the head is vertical, or slightly inclined backward, but in some (*Tryxalinæ*) it is much inclined backward, and the whole head seems prolonged in a way that makes it look like a cone or wedge, with the antennæ and eyes near the apex, and the mouth placed below under its base. The *Acridiidæ* are usually provided with three ocelli in addition to the compound eyes, the ocelli being as a rule more distinct than in the *Locustidæ*. The mouth organs are well developed, consisting of a large upper lip; strong, toothed masticatory jaws; five-jointed maxillary palpi; and a lower lip, divided at the end into two or four

lobes, and bearing three-jointed palpi. The prothorax is generally large, much longer above than below, and often carrying a prominent crest along the middle. Wings are usually present, but the hind pair are wanting in the females, or even in both sexes, of some species. In their general life history the *Acridiidæ* are probably much alike. The female lays her eggs at a short depth below the surface of the ground, or attaches them to the stalks of grasses, and usually surrounds them, in mass, with some sort of protective covering. Later on in the same year, or in the spring of the year following, the larvæ are excluded. They soon become active, and — except that they are without wings, have shorter antennæ, and are of smaller size and no definite color — do not differ much in appearance from the perfect insects. After undergoing, as a rule, about six molts, the larvæ which are



MIGRATORY LOCUST OF SOUTHEAST EUROPE (*Pachylylus migratorius*) AND ITS LARVÆ. (Natural size.)

hatched in the spring become adult late in the summer. It is generally in the days immediately following their entry into the perfect state that the male insects are loudest and most persistent in their song. Few of the British *Acridiidæ*, of which there are about a dozen, are remarkable for the brightness of their colors; nor do any cause trouble by a great excess of numbers. But among the exotic species there are many exhibiting vivid tints of color; and some which are capable of multiplying to such an extent as to become a serious source of mischief in the places where they abound. It is to the species accustomed to assemble together, and migrate from place to place, in vast swarms, that the name of locusts is more especially applied; this habit really constituting almost the only difference between the locusts and many of the other grasshoppers of this family. Grasshoppers feed

chiefly on the grasses of different kinds, including most of the cultivated grains; but locusts leave scarcely anything in the nature of vegetation untouched, when, as often happens, they invade a district where the ordinary herbs and grasses are insufficient to support their vast numbers. Trees and shrubs are then stripped bare of their leaves, and the bark and wood even are not spared. Pressed by hunger, locusts do not refrain from attacking plants which at ordinary times they seem to avoid. They frequently devour their own dead, and even carry their cannibalism so far as to kill and eat the newly-molted and soft-skinned larvæ. Different species of these destructive insects are found in all the great regions of the world; though North Africa is, perhaps, the one which suffers most from their ravages. The locusts referred to in Scripture belonged in all probability for the most part to the species known as *Schistocerca peregrina*, which has its chief home in the Sahara and surrounding districts.

Several other species are found in North Africa, and in South Africa *Pachytylus migratorioides* is one of the most widely distributed. Great swarms of locusts of this species have been seen at different times in recent years; one which passed over Pretoria in 1891 was estimated to be twenty-five miles long, one and a half broad, and half a mile in depth. It was probably to this species also those locusts belonged, of which Barrow, giving an account of their ravages in the year 1797, states that the whole surface of the ground over an area of about two thousand square miles was literally covered with them; and that when driven into the sea by a northwest wind, they formed a bank on the shore three or four feet high and fifty miles long. Among European locusts, the best known is *P. migratorius*, which occurs chiefly in the southeast, and is found also in Egypt and in West and Central Asia.

Passing from the locusts, we may briefly notice a few of the other insects of the family. The *Tryxalinæ* are remarkable on account of the peculiar shape of their head, to which we have already alluded. No species of this subfamily is found in Britain. In the allied *Tettiginæ* the pronotum is produced behind into a long process, which in some of the species reaches beyond the tip of the abdomen. Two of the smallest species of grasshoppers found in Great Britain belong to the genus *Tettix* — the typical genus of this subfamily. The genus *Pneumora*, which is represented only in South Africa, is characterized by the bladder-like dilatation of the abdomen in one of the sexes. The hind-legs in this genus are rather short, and are scarcely adapted for leaping.

Tettix subulata.
(Natural size.)

The stick and leaf insects (*Phasmatidæ*) are chiefly interesting on account of their resemblance to the objects after which they are named. They form one of the

Stick and Leaf Insects

families of Cursorial Orthoptera, and, in addition to the easily recognized shape of their bodies, are distinguished by the following characteristics: The head is distinctly visible from above, and is set somewhat obliquely, with the mouth placed well forward on the under side. The short prothorax is much shorter, as a rule, than the next segment, or mesothorax. The legs which, in shape, usually harmonize with the shape of the body, are inserted somewhat close to the sides of the thorax, those of each pair being separated from one another by a rather broad sternal plate; the tarsi are five jointed, and exhibit a pad-like lobe between the claws of the terminal joint. In the stick insects the trunk is long, narrow, and cylindrical; the legs are generally long, and, when stretched out unsymmetrically from the body, as they habitually are in the resting insect, look like smaller branches coming off from a thicker, jointed stem. Many stick insects have no wings at any stage of their life, and it is difficult, in such cases, to distinguish the adult insects from some of the older larvæ. In the winged species the fore-wings are usually very short, and often cover only a small part of the hind

ONE OF THE STICK INSECTS OF SOUTH EUROPE (*Bacillus rossi*) AND ITS LARVA.
(Natural size.)

pair; the latter exhibit a division into two distinct areas — one more membranous and transparent, and often brightly colored; the other, which is narrower, and placed next the anterior border, being colored like the elytra. When the wings are at rest, the brightly-colored portion is folded beneath the other part, which alone is then exposed to view, so that there is nothing to detract from the general stick-like appearance of the body. These insects are usually found among underwood, or on shrubs and the stems of long grasses. They are mostly inactive during the day, and are not easily seen owing to the way in which their form and colors harmonize with their surroundings. They roam about at night, and feed upon leaves. Most inhabit tropical and subtropical countries, and among them are some of the largest insects known, more than one measuring over thirteen inches in length. Two species are found in South Europe, belonging to the genus *Bacillus*, and are both wingless forms of rather small size. One of these is figured in the illustration; and, as examples of some of the more finely-colored tropical forms, two species from the island of Borneo are represented on the colored plate of Orthoptera.

The leaf insects, though belonging to the same family, exhibit a marked contrast to stick insects in the shape of the body, which, instead of being narrow and cylindrical, is broad and flat. The male is narrower than the female, and distinguished also by having moderately long antennæ, well-developed hind-wings and short fore-wings. In the female the antennæ are very short, the hind-wings are rudimentary; and the elytra are fairly large, leaf-like structures, which, in some species, almost entirely cover the broad, flattened abdomen. The legs have broad, leaf-like expansions on both the femora and tibiæ, contributing to the general leaf-like appearance. It is remarkable that the color of these insects, which is either the green of a living leaf, or some shade of yellow or brown, like that of a withered leaf, is due to a substance similar in its nature to chlorophyll, or the green coloring matter of plants; and it is stated that the internal structure of the elytra bears a striking resemblance to that of a plant. All these curious insects belong to the single genus *Phyllium*, and are found in the Oriental countries, and in some islands of the Indian Ocean.

Praying Insects

The praying insects, or *Mantidæ*, constituting the next family of the suborder, have the head turned down, with the face inclined backward, so that the vertex projects in front, while the mouth lies close to the lower edge of the prothorax. They have many-jointed, bristle-like, or comb-like antennæ. The prothorax is generally much longer than the other two segments of the thorax taken together; whereas the two hinder pairs of legs are long, and

PRAYING INSECT SEIZING A FLY.

The egg case and some of the escaping larvæ are shown at the left-hand side of the figure.

resemble one another. The fore-legs — which are inserted close to the front and wider end of the prothorax — exhibit a peculiar form and structure, their coxæ being long and three cornered, and often spined on the angles, and the femora broad, flattened, and grooved below to receive the tibiæ, which can be folded back upon them like the blade of a knife. The tarsi of all the legs are five jointed. These insects usually have two pairs of wings, of which the fore-wings, or elytra, are ordinarily of the length of the abdomen. The characteristic posture which these

insects assume when resting on a tree or shrub with their prothorax raised, and the fore-legs doubled up in front of them, accounts for their common names of soothsayers and praying insects. They are among the most predaceous and bloodthirsty of creatures, living on flies and other insects, which they seize with their raptorial fore-legs, in the manner shown in the illustration. *Mantidæ* are chiefly found in the warmer parts of the world, but a few species occur in South Europe.

EGG CASE OF THE COMMON KITCHEN COCKROACH.
(The top figure natural size, the others much enlarged.)

The best known of these is the figured *Mantis religiosa*. Some species, such as the African *Harpax ocellata*, shown on the colored plate, are curiously marked, while others are prettily colored. The colors are sometimes so disposed that the insect in its resting attitude resembles a flower, and thus draws toward it other insects, which, when they have approached near enough, are suddenly caught, as if in a trap, by the arms of the deceiver.

Cockroaches

The cockroaches (*Blattidæ*) constitute one of those families in which the legs are more specially fitted for running. They have a rather

COCKROACHES.
1. *Phyllodromia germanica*, male and female; 2. *Ectobia lapponica*.
(Natural size.)

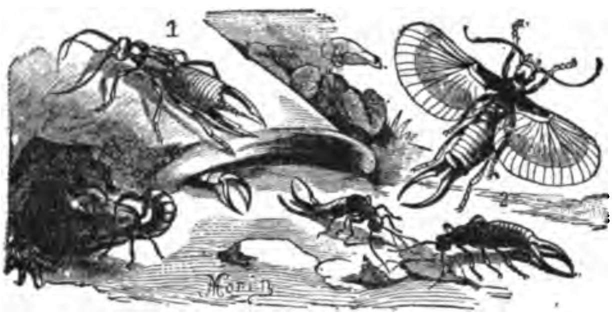
short head, with a large, flat face, looking slightly downward, and the mouth brought close to the prosternum. The eyes are large and compound, and in the place usually occupied by the lateral ocelli there are often to be seen two pale soft spots in the integument. The long and tapering antennæ are inserted close to the

eyes, and composed of a stouter basal joint, followed by a number of short joints. The strong and horny jaws are toothed or spined on the inner side, and thus well adapted to biting; and the head is scarcely visible from above, being overlapped by the large, shield-like plate of the prothorax. The legs are long, with spiny tibiæ, and end in five-jointed tarsi. The pulvillus, which projects between the tarsal claws of these and many other insects, constitutes a sixth joint, although not usually reckoned as such. Cockroaches are generally provided with two pairs of wings, the front pair being stiff and horny, while the hind pair are of a more membranous texture, and, in a state of rest, are folded longitudinally, and almost entirely covered by the elytra. The abdomen is broad and flat, and carries two jointed appendages — the cerci — near its extremity. About six species are found in Britain, of which three only are really indigenous, the others having been imported. The common cockroach (*Periplaneta orientalis*) is believed to have belonged originally to the East, though now found in almost all parts of the world. These insects are commonly spoken of as "black beetles," though not beetles, and not black, but having a reddish-brown color. The male is easily recognized by the wings, of which there are two pairs, scarcely reaching beyond the middle of the abdomen. The female is broader in the body, and has very short rudimentary fore-wings and no hind-wings. Her eggs are arranged in a horny case, opening at the top, and shaped like a purse, which she carries about with her for some time, protruding from the end of her abdomen. She finally deposits the egg capsule in a crevice in the walls or below the floor, and after some interval the young larvæ are excluded. During growth they shed their skin several times. The new skin is at first soft and of a pale or nearly white color, but gradually hardens and gets darker. The American cockroach (*P. americana*) which is such a pest on many ships, and is found about the docks and warehouses of seaport towns, is larger than the common species. Although it somewhat resembles the latter in general color, it has two pale bands on the prothorax, and is winged in both sexes. The German cockroach (*Phyllodromia germanica*) is another imported species, said to have first arrived with the soldiers returning from the Crimean War, but now plentiful in some houses, especially in bakeries and restaurants. It may be distinguished by its smaller size, and pale yellow-brown color, with two dark brown bands along the pronotum. Both sexes have wings. In some parts of Central Europe they live in woods, resembling in this respect many other species, including three, belonging to the genus *Ectobia*, found in woods in England. One of the latter (*E. lapponica*) enters houses in some parts of Europe.

Earwigs

The earwigs (*Forficulidæ*), which form the last family of Cursorial Orthoptera, possess distinct characteristics, and are sometimes treated as a separate order, under the name of Dermaptera. Easily recognized by the narrow body, short, squarely cut horny elytra, and the pincer-like appendages of their abdomen, these insects are further distinguished by the intricate folding of the hind-wings. The elytra, or fore-wings, do not overlap one another as in most Orthoptera, but, like those of beetles, simply meet by their edges along the middle line. The hind-wings, which are thin and membranous throughout most of their extent, are folded, partly like a fan, by means of folds radiating from near the middle

of the anterior margin, and also transversely. In this way they occupy a small space, and are almost completely covered by the elytra, a tiny piece only being left projecting behind. When fully expanded, each wing is somewhat elliptic in outline, with a straighter anterior and more rounded posterior margin. To these characteristics it is only necessary to add that the tarsi are three jointed, and the ligula of the lower lip is deeply divided, to form two long lobes. This family is represented in almost all parts of the world, but not more than two or three species are commonly met with in Britain. The species are distinguished chiefly by the size and shape of their forceps, the length and number of joints of the antennæ, the state of development of the wings (which in some species are altogether wanting), the length and shape of the tarsal joints, and other characteristics. The common earwig (*Forficula auricularia*), found all over Europe, is the best-known species. The female is usually smaller than the male, and her forceps are shorter, and without teeth at the base. Her eggs are laid under stones, moss, or in other such places; and she watches over them with care. It was long ago observed that the female earwig sits over her eggs, like a hen in a nest, and if they happen to get scattered, gathers them all together again. The young lárvæ when hatched keep close to her, clustering under her body, and sometimes climbing on to her back. They are not very unlike their mother in appearance, but are without wings, and of much smaller size. The large earwig (*Labidura riparia*), found somewhat rarely in England along the south coast, is nearly twice the size of the common species, and its forceps has a large tooth beyond the middle of its length.



1. MALE OF THE LARGE EARWIG; 2. THE COMMON EARWIG WITH AN ENLARGED FIGURE OF THE FLYING INSECT.

Order RHYNCHOTA

The numerous insects included in this order exhibit great differences in their external form, and while some, such as the *Flatinæ*, rival the butterflies and moths in the beauty and delicacy of their colors, others are among the most loathsome of creatures. But whatever be their form or color, all agree in two essential characteristics, the first consisting in the fact that their development takes place without a complete metamorphosis; and the second that all have the mouth taking the form of a beak, or rostrum, adapted for piercing and sucking. The beak consists chiefly of the lower lip (labium), which is long and narrow, composed of three or four joints, and grooved along the whole length of its upper or anterior surface. This groove forms a sort of sheath, in which are lodged four long slender blades.

corresponding to the mandibles and maxillæ of other insects, but here transformed into piercing organs. All these parts are covered at the base in front by the narrow and slightly elongated upper lip (labrum). From the structure of their mouth, which is fitted only for the reception of liquid nutriment, it is easy to infer that these insects live by piercing tissues of plants and animals, and extracting the juices. The larvæ differ little from the adults except in size, the absence of wings, and their usually shorter and more slender antennæ. In many, however, the females are without wings at all stages; and in some cases both sexes are thus unprovided. When wings are present, they may be all of similar texture, or the front pair may be somewhat stiffer and less membranous than the hinder. Wings of both these kinds are found in the section Homoptera. In other cases, while the hind-wings are entirely membranous, the front pair are stiff and horny for some distance from their base, and thin and membranous toward their extremities. Such wings, which characterize the section Heteroptera, are known as hemi-elytra. Over eighteen thousand species are already known. Fossil remains of the order are found in strata of the Jurassic epoch, and are tolerably abundant in amber and other beds of Tertiary age.

All the Heteroptera, no matter how different they may be in external form or mode of life, are termed bugs, although this name was originally applied only to the bedbug and a few closely-allied species. Most are winged insects, in which the fore-wings known as hemi-elytra, or simply as elytra, always have the form described. Their antennæ are either short and inconspicuous, as in the water bugs, or distinctly visible as in the land bugs, and are generally composed of a small number of joints. As a rule, they have two compound eyes, and often two or three ocelli. The first segment of the thorax is usually large, with the head sunk deeply into it. The abdomen generally has an oval flattened form, and the legs are mostly slender. With few exceptions bugs are characterized by a peculiar and somewhat unpleasant odor, which arises from a liquid secreted by special glands placed in the front part of the abdomen, and opening to the exterior by means of two small ostioles on the ventral surface of the metathorax.

Land Bugs

Bugs are divided into two tribes, based upon their mode of existence, and the fact that in one tribe — the land bugs, or Geocorisa — the antennæ project, and are distinctly visible, while in the other — the water bugs, or Hydrocorisa — they are very short, and hidden below the eyes. The shield bugs (Pentatomatidæ), which constitute one of the largest families of the Geocorisa, are so called on account of their large scutellum, which reaches at least to the middle of the abdomen, and sometimes quite to its extremity, covering it over completely. The fore-wings are sometimes chitinized only near the basal margin, especially in those species with a very large scutellum. The body has in general an elliptical outline, or is shaped like a scutcheon, owing to the projecting lateral angles of the somewhat hexagonal pronotum. These bugs are mostly found on low plants, some in concealment, many showing themselves openly, and often attracting observation by their striking colors. The adults pass the winter sheltered under bark or dried leaves. In early spring the females lay their eggs on the foliage of low plants, shrubs, and pine trees. The oval or spherical eggs are provided with an

operculum, or lid, and disposed in patches resembling honeycomb. The larvæ molt several times in the course of their growth, and thus gradually effect a change in their form and coloration. They feed on the juices of plants, or, in some cases, of animals, and attain their full size toward the end of summer. The European species are rather limited in number; but many forms are found in other parts of the world. The Hottentot bug (*Eurygaster maurus*) is the name given to a species with a very large scutellum, found throughout nearly all Europe. It is cf a yellow, dark brown, or black color, with two clear spots on each side of the base of the scutellum. Some rather pretty bugs of the genus *Scutellera*, belonging to the same subfamily, and characterized by a similar large scutellum, are found in Australia and the Eastern Archipelago. They are of a short, broad, and convex form, and have a very fine metallic-blue coloration, often spotted with bright yellow. The forest bugs (*Pentatoma*) have strongly projecting angles to the prothorax, and have a long triangular scutellum. The species figured (*P. rufipes*) is common throughout Europe, on birch and other trees, and renders service by destroying certain caterpillars. In the accompanying illustration three other species of this family—*Acanthosoma dentatum*, which is common on willows; *Eurydema oleraceum*, a bluish-green or metallic-green species, with red or white markings, which in some places is injurious to plants of the cabbage tribe, but also lives on other plants, and has often been seen to prey upon insects; and another common species met with near the outskirts of woods and in fields and meadows.

HOTTENTOT BUG.
(Natural size.)

SHIELD BUGS.
1. *Pentatoma rufipes*; 2. *Acanthosoma dentatum*; 3. *Eurydema oleraceum*; 4. *Aelia acuminata* (natural size).

The family *Coreidæ* includes a number of land bugs, which vary a good deal in form, but which possess in common the following characteristics,—antennæ four jointed, set rather high up on the head; two ocelli generally present; scutellum short and triangular; elytral membrane strongly and thickly veined. These bugs mostly

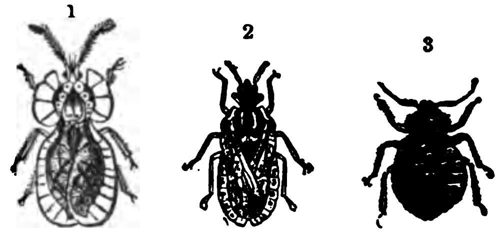
inhabit the warmer parts of the world, not more than about sixty species being found in Europe. Their habits are not very well known. Some of the European species live during the winter under leaves, and when disturbed in their retreat make by their movements a peculiar rustling sound. In summer they are to be found among herbs and shrubs seeking their food, or they may sometimes be seen flying actively in the sunshine. Our figures — one representing a stout, strongly-built insect (*Syromastes marginatus*), the other a species (*Neides tipularius*) with a body as slender almost as that of the daddy longlegs — illustrate what considerable differences of form are met with in this family, even among the common European species. The *Lygæidæ*, the next family of land bugs, may be characterized as follows, — antennæ four jointed, arising from below an imaginary line drawn from the middle of the eye to the base of the rostrum; two ocelli usually present, and placed close to the compound eyes; sheath of rostrum composed of four nearly equal joints; scutellum short and triangular; membrane of elytra traversed by four or five longitudinal veins. They live, for the most part, under stones, dead leaves, or moss at the foot of trees, where they are often found together in large numbers; and it is from their love of such obscure places that the name *Lygæus* has been given to the typical genus. They feed on the juices of plants or the dead bodies of other insects. A few species only show themselves in broad daylight. The species of the genus *Pyrrhocoris*, and others associated in the same subfamily, are distinguished by the fact that they have no ocelli. *P. apterus* is a common and widely-spread European species, occasionally met with in Britain, which may be known by its red and black colors, and the want of hind-wings, as well as of a membranous part to its elytra. The plant bugs (*Phytocoridæ*) have the following characteristics: Head triangular in shape, tricarinate above, and without ocelli; antennæ long, four jointed, with the second joint longest, and the last two very slender; rostrum four jointed, resting against the under side of the thorax, and almost reaching to the end of it; tarsi three jointed; elytra with an *appendix*, or small angular piece, divided off by a transverse suture from the rest of the coriaceous part of the elytra, and coming between it and the membrane. This family is well represented in temperate regions, and about three hundred European species are known. They are mostly soft-bodied, fragile bugs,

1. *Syromastes marginatus*; 2. Larva of the same; 3. *Neides tipularius*. (Natural size.)


Phyrrhocoris apterus (three times the natural size).

presenting a considerable variety of color, of which green is in many cases the predominant tint. They live principally on honey, and are to be found on flowers and in meadows. *Phytocoris tripustulatus*, a species with black elytra, marked with three orange spots on the outer margin, is common on nettles. We give an enlarged figure of another species (*Calocoris striatellus*), widely distributed throughout Europe, and met with chiefly on umbelliferous plants. The *Acanthiidæ* form a family of mostly very small bugs, which are usually without ocelli, and have a three-jointed beak — lodged in a groove along the under side of the head — and two-jointed tarsi. These bugs frequently have a somewhat peculiar appearance, owing to the membranous or vesicular lobes with which the thorax, abdomen, and elytra are often furnished. For this reason they are sometimes known as membranaceous bugs. The species of the genus *Tingis* are seldom more than one-sixth of an inch long, and distinguished by the knob-like ends to their antennæ, as well as by the foliaceous expansion of their thorax, and the extension of the latter behind to cover the scutellum. The common *T. affinis* may be recognized by the brown color of its body, its transparent borders, with transverse brown nervures, and the ×-shaped spot on the middle of each elytron. This species may be found on sandy soil among the roots of grasses, or under plants, such as wormwood, belonging to the genus *Artemisia*. Another species (*F. pyri*) is noted for the injury it does to pear trees, by pricking holes in hundreds on the under side of the leaves and extracting the sap. It is of a brown color, with pale yellow or white elytra, marked with a brown spot at the base and another at the extremity. *Aradus corticalis* is a common species, found under bark, which we figure to give an idea of the flattened form and membranous appearance of the bugs of the subfamily *Aradinæ*. These bugs have a longer rostrum and more cylindrical antennæ than those of the *Tingitinæ*. The bedbug (*Cimex lectularius*), which also belongs to this family, is a wingless species, with four-jointed antennæ, and a beak composed also of four joints, which can be turned back to lie in a groove under the throat. The shape of the insect may be seen from the figure, as well as the two lobes lying at the sides of the scutellum, which are all it has in the way of elytra. Closely-allied species are found in dovecots, and in the nests of martins and bats. The *Reduviidæ* are predaceous bugs, in which the head, narrowed behind in the form of a neck, carries two ocelli in addition to the compound eyes. Their antennæ are composed of four joints, though these are often subdivided in such a way that the number may appear much greater. The rostrum is short

Calocoris striatellus (much enlarged).

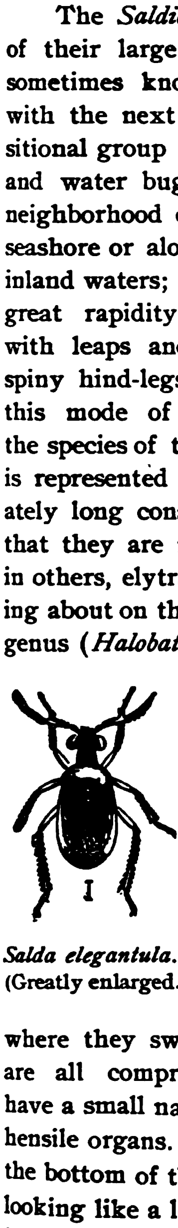


1. *Tingis affinis* (×8); 2. *Aradus corticalis* (×6); 3. *Cimex lectularius* (much enlarged).

and strong, and three jointed; their legs are long, and have three-jointed tarsi; and the fore-legs often serve as prehensile organs, their tarsi being specially adapted for that purpose. *Reduvius personatus*, the largest British species, is three-quarters of an inch long, of a black-brown color, with red legs, which, as well as the prothorax and antennæ, are some what hairy.

Reduvius personatus and its larva.
(Natural size.)

The *Saldidæ*, which, on account of their large projecting eyes, are sometimes known as Oculati, form with the next family a sort of transitional group between the land bugs and water bugs. They live in the neighborhood of water, either by the seashore or along the sandy banks of inland waters; and not only run with great rapidity, but often advance with leaps and bounds, their long spiny hind-legs being well fitted for this mode of locomotion. One of the species of the typical genus *Salda* is represented in the illustration. The pond skaters (*Hydrometridæ*) have moderately long conspicuous antennæ, and present other points of structure showing that they are nearly related to the true land bugs. In some species wings, and in others, elytra also, may be wanting. These insects may be seen walking or gliding about on the sunny surface of stagnant or slow-flowing waters; and those of one genus (*Halobates*) are found on the surface of the sea, sometimes right out in mid ocean. The true pond skaters (*Gerris*) move about very quickly on the surface of the water, and use their fore-legs in seizing their prey. *Limnobates stagnorum* is a more sluggish insect, walking slowly on the surface of the water, or on the grassy banks; and is remarkable for its elongated slender body, whence its name of needle bug or water gnat. This species is figured on p. 3158, together with *Gerris paludum* and the larva of *Velia currens*.



Salda elegantula.
(Greatly enlarged.)

Water Bugs

The water bugs, Hydrocorisa, are distinguished from the land bugs, not only by their mode of life, but also by their short inconspicuous antennæ, and are mostly dull and uniformly colored insects, frequenting stagnant waters, where they swim, some on their back, others with the back uppermost. They are all comprised in two families. Of these, the water scorpions (*Nepidæ*) have a small narrow head, and their fore-legs are specially modified to serve as prehensile organs. Whereas some swim actively, others drag themselves slowly along the bottom of the ponds in which they live. They are furnished with an appendage looking like a long tail, but consisting of two separate pieces, grooved on their inner surface, and capable of being locked closely together to form a tube, which leads to the two spiracles placed at the hind end of the body. When the insects come up to breathe, the tip of this breathing tube may be seen emerging just at the surface of

the water. The form of the body is in some (*Nepa*) broad and flat; in others (*Ranatra*) elongated. The female of *Nepa* lays her eggs in chains on aquatic plants, and each egg has seven short processes radiating from one end. The eggs of the *Ranatra* are laid one by one in notches, which the female makes in the stems of the plant.

Certain exotic species of this family are remarkable for their great size, attaining in the genus *Belostoma* a length of over four inches. The water boatmen (*Notonectidæ*) may be recognized by the large broad head without ocelli, and the

COMMON BRITISH WATER BUGS.

1. The water boatman (*Notonecta glauca*); 2. The water scorpion (*Nepa cinerea*), with (3) its larva and (4) its eggs; 5. *Naucoris cimicoides*; 6. *Corixa geoffroyi*; 7. *Ranatra linearis*; 8. *Limnobates stagnorum*; 9. Pond skater (*Gerris paludum*), with (10) its eggs and larvæ; 11. Larva of *Velia currens* (natural size).

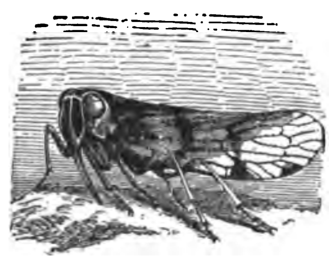
short thick rostrum. They have long hind-legs fringed with hairs on one side, which they use like oars in swimming. When the insect comes to the surface to breathe, it rests with these long legs, stretched out like a boatman leaning on his sculls. Though the name *Notonectidæ* has reference to their mode of swimming on the back, this habit is not characteristic of all the species. All are predaceous bugs, like all the rest of the same tribe, and are found abundantly in stagnant waters. Two of the common species, *Notonecta glauca* and *Corixa geoffroyi* are figured on p. 3158.

The Homoptera present much greater variety in external form than the insects of the preceding group, from which they differ in the following characteristics: The beak arises from the lower and hinder part of the head, and is, therefore, almost completely hidden from view. The fore-wings are, when present, of the same texture throughout the whole of their extent, and, in many cases, placed slanting, like the sides of a roof, when at rest. All the members of the section live by sucking the juices of plants; the females being often provided with a horny ovipositor—generally composed of three toothed plates, sheathed by two valves—for the purpose of making incisions in plants where the eggs are deposited. Unlike most bugs, they are not odoriferous insects, although many have special glands for the secretion of a kind of white waxy substance, often seen covering part of their body. The cicadas (*Cicadidæ*) are stout-bodied insects, with a short broad head, bearing prominent lateral eyes, and three distinct ocelli, which are often brightly colored and resemble tiny jewels set near the middle of the forehead. The short antennæ are like small bristles inserted on the sides of the head just below the front margin of the eyes. The prothorax is short and broad, and the mesothorax also broad, on the upper side stretching back some distance behind to form a kind of shield. The fore-wings are longer than the hind pair, both being often glossy and transparent, but sometimes finely colored and more or less opaque. Cicadas remain for a long period in the larval state, in many cases for several years; a North-American species, *Cicada septemdecim*, being known as the seventeen-year locust, since that period is the interval between one generation of winged insects and the next. They inhabit chiefly the warmer regions of the earth, of the four or five hundred species known, not more than eighteen being found in Europe, and these mainly in its southern parts. The song of the cicadas, which has been celebrated from very early times, is only produced by the male insects. "Happy," writes a Greek poet, "are the cicadas' lives, for they all have voiceless wives." The females are necessarily silent, since they are without the special apparatus for producing sound distinctive of the males. The two scaly plates which in the latter cover the under side of the base of the abdomen, are not, as sometimes supposed,

EUROPEAN CICADAS.
1. *Cicada orni*; 2. *C. plebja* and larva.

the sound-producing organs. But if one of them be stripped off, there will be disclosed a cavity, divided by an oblique horny ridge into two portions, the inner one somewhat irregular in shape, and exhibiting tense glistening membranes in the walls, while the outer portion is narrow and opens by a narrow mouth toward the side. Hidden in the wall of the latter chamber lies the membrane which is the chief organ concerned in the production of sound. These membranes are set in vibration by the contraction and relaxation of a pair of strong muscles attached to their inner faces and lying inside the body. The other membranes in their neighborhood seem to serve the purpose only of modulating the sound. The cicadas figured are two of the commoner species from South Europe. Both live on ash trees, although *Cicada orni* selects by preference the manna ash. The specimen with its under side exposed may be easily recognized as a male, on account of the two plates, or opercula, covering the cavities in which the sound apparatus is lodged.

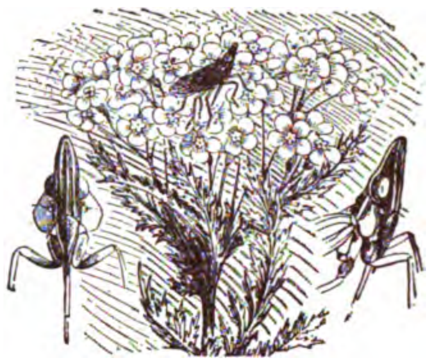
The lantern flies and other insects included in the family *Fulgoridæ* are characterized by never having more than two ocelli, these being placed, one on each side, near the inner margin of the compound eyes. The latter are not large, and below them are inserted the short and inconspicuous antennæ. The front, vertex, and sides of the head are usually separated from one another by sharp crests, and the head itself is in some cases greatly prolonged in front. The fore-wings are either similar in texture to the hind pair or else somewhat harder and more leathery. The Chinese lantern fly (*Hotinus candelarius*), so widely distributed in Asia, is one of the best known, the common names said to be given to it in China being very suggestive of its luminosity, although so far there is no trustworthy evidence to show that it possesses any such property. Lantern flies are nearly all prettily colored; and of the other insects belonging to the same family there are some, like those of the genus *Flata*, rivaling in the delicacy of their colors the most beautiful butterflies or flowers; while others, as in the genus *Flatoides*, exhibit that curious mixture of gray and black, which, in combination with the flattened form of their bodies, gives them the most astonishing resemblance to lichen-covered bark. The species of *Flata* and other genera are remarkable also for their white tufted tails of wax, which are found more especially in the larvæ, but are often present only in the winged insects. These insects do not stir far from their food plant, on which they may be seen both in the larval and adult state, clustered together in large numbers, somewhat after the manner of plant lice. The European species of *Fulgoridæ* are not remarkable for their size or the brilliancy of their colors. *Issus coleoptratus* is perhaps the largest British species, and we figure *Cixius nervosus*, another widely-distributed British and European species, together with *Pseudophana europæa*, the sole representative in Europe of its genus, and sometimes spoken of as the European lantern fly.



Cixius nervosus.
(Enlarged.)

The frog hoppers (*Cercopidæ*) are mostly small insects with a short broad head and stiff opaque elytra. They usually have two ocelli placed on the vertex of the head between the compound eyes; and their antennæ are inserted, not below the eyes as in

the *Fulgoridæ*, but between and a little way in front of them. These insects can give most vigorous leaps, and their hind-legs are generally thickened or otherwise adapted for that purpose. They feed on various plants, and in the summer the frothy masses in which their larvæ lie concealed may be seen in numbers. It is from this habit the larvæ have of surrounding themselves in a mass of froth, known as cuckoo spit, that the name *Aphrophora* (froth-bearing) has been given to one of the principal genera. A species of that genus is shown in the accompanying illustration, where another form (*Ledra aurita*)—remarkable for an ear-like lobe on each side of the prothorax—is also figured. The family *Membracidæ* includes mostly exotic insects, which have in many cases an extraordinary appearance, owing to the shape of the prothorax, or the curious way in which it is armed with spines or knobs, or with both combined. In these insects the head is somewhat vertical, and usually placed rather low down; it carries very short antennæ inserted near the front margin; and there are two ocelli between the compound eyes. The family is best represented in tropical America, very few species being found in Europe, and two only in Britain. *Centrotus cornutus*, one of the two latter, may be recognized by the form of its prothorax, which carries on each side a horny spine, and is prolonged behind in another horny process, reaching almost to the end of the body.



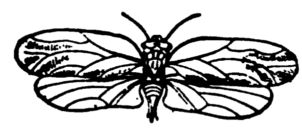
Pseudophana europæa.

1. *Ledra aurita;* 2. The same seen from the side (both enlarged); 3. *Aphrophora spumaria;* 4. Larva of the same.

The leaf fleas (*Psyllidæ*)—included with the next two families in that section of the order to which the name Phytophthires has been given—are little jumping insects, winged in both sexes, and using their wings not so much for the purpose of flying as to assist in their leaps. They have moderately long antennæ, consisting of eight or ten joints, and are thus easily distinguished from the *Cercopidæ*. The head is provided with three ocelli, in addition to the compound eyes; and the tarsi are two jointed. Owing to their method of locomotion, these insects are not liable to be mistaken for plant lice, although, like

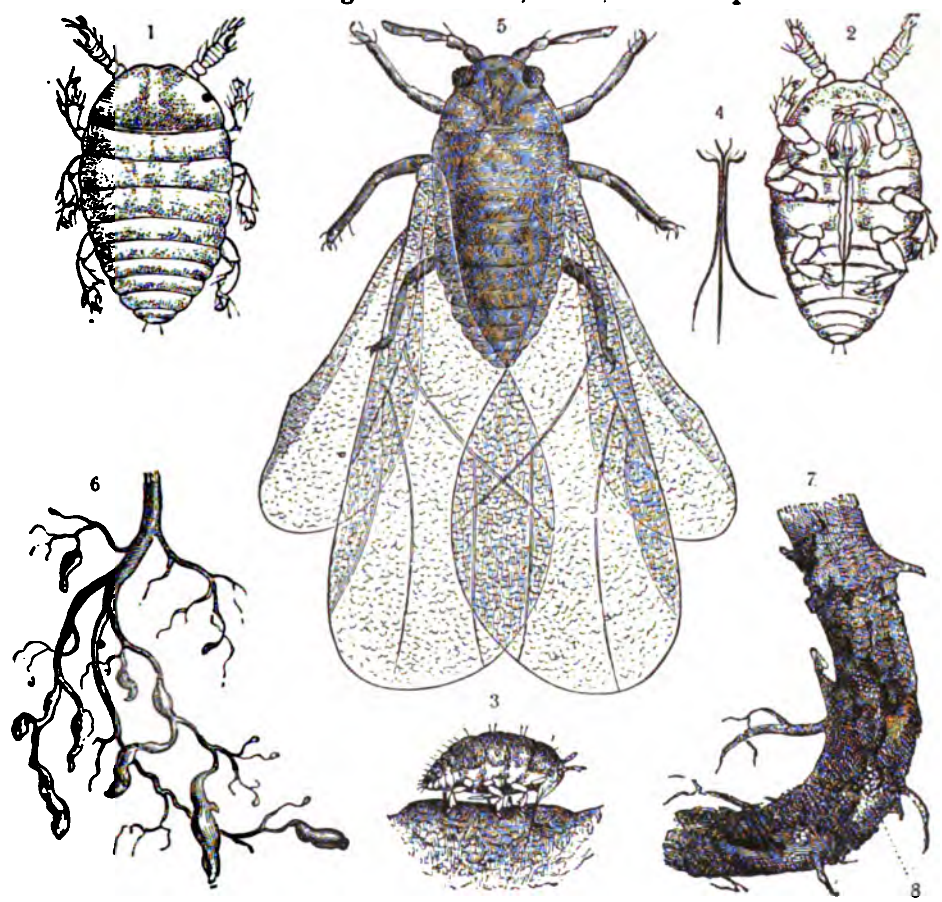
these insects, they infest the leaves and buds of plants. They prick the leaves to feed on the sap, their puncture being often followed by the formation of gall-like swellings. The figured *Psylla genistæ* feeds on the broom, but other species are found on apple and pear trees. The plant lice (*Aphidæ*) are small insects, which make up in numbers what they lack in size, and owing to the injury they inflict on plants, must be ranked among the greatest pests with which the gardener and horticulturist have to contend. They are those soft pulpy little creatures, with rather long antennæ and conspicuous round eyes, so commonly seen crowded together on the under side of leaves, in buds and flowers, in clefts in the bark of trees, and sometimes even on the roots. The antennæ are composed of from three to seven joints, on some of which are a number of curious rounded pits, probably of a sensory nature. The eyes are placed on the sides of the head, and each has often a sort of supplementary eye attached to its hind border; while in the winged aphides there are three ocelli on the crown of the head. The beak is composed of three joints; and the tarsi are two jointed and terminate in two claws. Wings, as a rule, are found only in the adult males and in some of those generations of asexual individuals to be mentioned presently. The fore-wings are longer than the hind pair, and placed in repose like a roof over the hind part of the body. Both pairs have a scanty venation, consisting in each wing of a single longitudinal vein, and of some simple or forked branches given off obliquely from it. The number of species is considerable, and there is scarcely a single kind of plant that does not suffer as the special host of some one or more. Many are green, whence the name of green fly by which they are commonly known; others are black, red, or some other color. They are usually named after the plants on which they more particularly live, though each species is not necessarily confined to one kind of plant. Thus we have the plant louse of the rose (*Aphis rosæ*); the green aphis of the apple (*A. mali*), which is found also on the pear and sloe tree; the cherry aphis (*A. cerasi*), and a host of others named in the same manner. The life history of plant lice is very complicated; and although differing somewhat in different species is always characterized by what is known as an alternation of generations. There are several broods or generations of these insects in the course of a year, but it is only in the last autumn brood that true sexual individuals are found. The males are generally provided with wings, but the females are larger and wingless; they lay fertilized eggs, from which, in the following spring, the first brood of the year is produced. The insects of this brood are usually wing-

Centrotus cornutus.
(Slightly enlarged.)



Psylla genistæ.
(Six times natural size.)

less, and give birth to living young, or, as in the genus *Phylloxera*, lay eggs from which the young subsequently develop. The new brood, thus produced parthenogenetically, resembles the one from which it has sprung, and gives rise to a fresh brood in a similar manner. As many as nine or ten generations may succeed one another in this way during the course of the season, before the appearance in the autumn of the last or sexual generation. The brood preceding and giving rise to the latter often consists of winged individuals, which leave the plant on which they

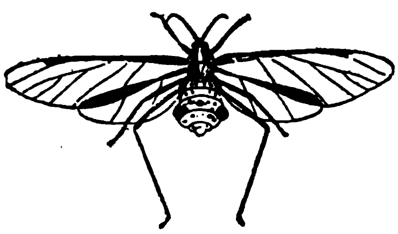


VINE PHYLLOXERA (much enlarged).

1 and 2. The wingless form found on the root, seen from above and below; 3. The same from the side; 4. Its piercing organs; 5. Winged individual; 6. Rootlets of the vine, with swellings caused by the Phylloxera; 7. An old root stock, with (8) hibernating individuals.

were born and fly to some other. In the genus *Phylloxera*, the males are wingless and each of the sexual females lays but a single egg, known as the winter egg; but in other forms the number is often much greater. Each of the parthenogenetic females of *Phylloxera* may in the course of its life lay as many as two hundred eggs, and each of the viviparous females of other species may give birth before they die to forty or fifty young. When we consider that there are several generations every year, it can be easily understood how it is that these insects spread with such rapidity;

and a sum in geometrical progression would show that the individuals which might arise in the course of a year from a single winter egg of *Phylloxera*, are not to be counted by hundreds or thousands, but by millions. Other species are capable of multiplying as rapidly. Fortunately, plant lice have many enemies, such as the larvæ of ladybird beetles, of lace-winged flies, and of the flies of the family *Syrphidæ*. These larvæ devour great numbers, and ichneumon flies also help to keep them in check. Plant lice are divided into a number of subfamilies, of which the first is represented by the genus *Aphis*. In this genus the antennæ are seven jointed and about as long as the body; the two horny tubes called *cornicles*, which project from the back of the abdomen, are also characteristic. Through these tubes the lice secrete a sweet kind of liquid much sought after by ants, who, in an affectionate way, come and caress the aphides in order to obtain it. The sticky substance known as honeydew, which is often spread in a shiny layer over the surface of leaves, is, in most cases, nothing but the liquid dropped by the crowns of plant lice living above on the under side of other leaves. The members of the allied subfamily *Lachninæ* have six-jointed antennæ, and instead of cornicles possess prominent grandular structures placed on the back of the abdomen. The figured *Lachnus punctatus* is found on the willow. The apple-blight insect (*Schizoneura lanigera*), which may be recognized by the white fluff covering in the wingless individuals the back of the abdomen, belongs to another subfamily. The winged individuals of this species are black, whereas those devoid of wings are of a yellowish or reddish-brown color, and live in the crevices of bark. The species is supposed to have been introduced from America, and was consequently at first known as American blight. In the genus *Phylloxera*—distinguished among other characteristics by the three-jointed antennæ—one species lives on the leaves of the oak tree, while a second (*P. vastatrix*) is the dreaded insect so destructive to the leaves and roots of the vine. These, like many other species of the family, cause the formation of galls on the leaves and roots which they attack. The curious galls with the appearance of small fir cones, so often seen on young shoots of the spruce fir, are caused by a species (*Chermes abietis*) remarkable for its complicated life history.



Lachnus punctatus.
(Six times natural size.)

The scale insects (*Coccidæ*), which owe their name to the fact that the larvæ and females of many species look like oval or rounded scales attached to the bark and leaves of plants, are very dissimilar in the two sexes. The adult males are provided with one pair of wings; the hind-wings being rudimentary or altogether absent; they have rather long antennæ, distinct eyes, and, in some cases, are furnished with two long bristle-like tails. These winged males are very rarely seen, which is accounted for by the fact that their mouth parts are atrophied, so that they are incapable of taking nourishment, and live only a short time. The females are always wingless, and usually remain fixed to one spot, with their beak buried in the tissues of the plant, and their back often spread out in the form of a shield covering the head and body. The beak is generally three jointed,

the antennæ are short, and in the tarsi, which appear at first sight to consist of but one joint, two or three joints may on close examination be distinguished, the last ending, as a rule, in a single claw. In many species the female dies shortly after laying eggs beneath her when her body dries up and remains as a protective cover for them. When the larvæ are hatched they soon leave this shelter, and rove about the food plant in search of a suitable place in which to insert their beaks and begin the operation of pumping up the sap. They cast their skin several times in the course of their growth; and those which become adult females undergo no great change in appearance, beyond an increase in their size, a gradual lengthening of the antennæ, and a partial or almost complete obliteration of the segmentation of their bodies. With the male larvæ the case is different; these, unlike all others belonging to the order, undergoing a true metamorphosis before reaching the perfect state. Each prepares for itself a sort of cocoon, and it becomes transformed into a quiescent pupa, from which, after a certain lapse of time, the winged insect emerges. In *Orthezia* and other genera the female, instead of keeping to one spot on the food plant, moves about and taps it at different points in order to extract the sap. When the eggs are laid, she envelops them in a kind of white cottony secretion and leaves them. Some species penetrate beneath the epidermis of their food plant, and often cause the formation of galls, which, growing up around them, sometimes take the most extraordinary shapes. Scale insects are probably more numerous within the tropics than in more temperate regions, although comparatively few of these tropical species have been described. These insects are found on the bark and leaves, and sometimes even on the roots of several different kinds of plants. They multiply rapidly, and often prove as injurious as the most noxious plant lice. The orange, apricot, olive, peach, fig, and other fruit trees, as well as ornamental shrubs like the rose, have each their own species, from which they sometimes suffer severely. Some years ago the orange plantations of California were threatened with ruin owing to the ravages of *Icerya purchasi*, which had been accidentally imported from Australia, and

SPRUCE-GALL APHID (*Chermes abietis*).
a. Larva; b. An older larva with its molded skin still attached to it; c. Winged insect; d. The gall.
(All enlarged.)

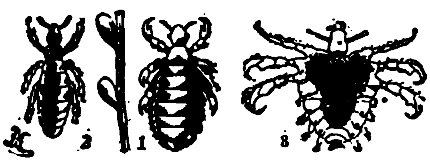

FEMALE OF *Orthezia urticæ*.
(Natural size.)

had spread with great rapidity. Experts were sent to Australia to try and discover the natural enemies of the insect in its native country; it was found that the scale insect was there kept in check by dipterous and hymenopterous parasites, but chiefly by the larvæ of a ladybird beetle. A number of these beetles and parasitic insects were brought to America, and set to prey upon the *Coccidæ*. When they had multiplied sufficiently, they were distributed among several orange plantations, with the result that many were soon almost entirely cleared of the scaly bug. Though many species of *Coccidæ* have to be combated because of their injuries, there are a few which are cultivated on account of the useful products they yield. Among these, the cochineal insect (*Coccus cacti*) is a native of Mexico and other parts of Central America, where it feeds on a species of cactus; but it has been introduced into Spain, Algeria, and a few other countries. The male is of a dark red color, with pale wings; the female has a reddish-brown color, but her body, which shows a distinct segmentation until the time of laying, is covered with

COCHINEAL INSECT (*Coccus cacti*), with enlarged figures to the left of (1) the male and (2) female.

a white powder. About seventy thousand dried bodies of these insects, chiefly females, are said to be contained in a single pound of cochineal. Long before the introduction of cochineal into Europe, two native species of *Coccidæ* had been used for similar purposes. The dye with which the ancients produced their deep red or crimson colors was obtained from *Cermes vermilio*, known to the Greeks as kokkos and to the Arabians and Persians as kermes or alkermes. Another species (*Porphyrophora polonica*), formerly known as the scarlet grain or Poland, is found in many parts of Central Europe, and was at one time extensively collected for the sake of the red dye it afforded. The lac insect (*Carteria lacca*) of the Oriental countries, not only furnishes the coloring matter called lac dye, but causes also an exudation of a resinous substance, gum-lac, from the bark of the trees on which it lives. Stick-lac is the name given to this substance in its native state while still adhering to the twigs of the tree; when separated, pounded and freed by washing from its coloring matter, it is known as seed-lac, which after further preparation becomes lump-lac or shellac.

The Pediculina, or true lice, as distinguished from the bird lice of the order Orthoptera, are provided with piercing and suctorial mouth parts, and live on the blood of animals, to which by this means they are enabled to gain access. Though they are without wings, and were at one time associated with other wingless insects in a separate order, lice are now generally regarded as degraded forms of Rhynchota, in which the wingless condition has been brought about as an adaptation to their parasitic life. In these insects the head is set horizontally, and carries short, cylindrical, and usually five-jointed antennæ; the eyes are small and simple; and the mouth consists externally of a soft, retractile beak, somewhat conical in shape, and furnished below with a row of hooks for attachment. Within the fleshy beak there are four grooved pieces, forming by their juxtaposition an inner membranous tube, which can be extended beyond its sheath, and acts both as a piercing organ and as a conduit for the passage of the blood which is sucked up by the insect. The thorax is small and not distinctly divided into segments, while the abdomen is relatively large, generally somewhat elliptical in outline, and exhibits seven or eight clearly marked segments. The tarsi are two jointed, with the second joint in the form of a claw which can be turned back toward the first. Lice multiply rapidly, one generation succeeding another in a short space of time. Their pear-shaped eggs are generally found attached to the bases of the hairs; the young, which are hatched after about eight days, undergo no metamorphosis, and, in some cases, require only about eighteen days before becoming adult.



1. HEAD LOUSE WITH ITS EGGS; 2. BODY LOUSE; 3. CRAB LOUSE. (All greatly enlarged.)

Order Thysanoptera

The insects comprised in this order — some of them familiar enough to gardeners and others, by whom they are known as thrips — are all small. A few species only exceed four or five lines in length, while the great majority are less than a tenth of an inch long. They are distinguished from all other insects by certain peculiarities in the structure of their mouth and of their wings and tarsi. The mouth lies far back on the under side of the head; its mandibles are transformed into a pair of piercing setæ, while the upper lip, maxillæ and labium — the two latter, provided with short palpi — are united together to form a short suctorial tube. The wings are small and narrow, contain few nervures, and are thickly fringed all round with long hairs. Two pairs of such wings are generally present, but in some cases they may be rudimentary or altogether wanting. The tarsi, which consist of one, two, or three joints, are without claws at the end, but are furnished instead with small vesicular lobes, by means of which they adhere to the surface on which they rest. To these characteristics of the order we may add that the body is narrow and cylindrical; the thorax is formed of three, and the abdomen of ten segments; there are only three or four pairs of spiracular openings — two on

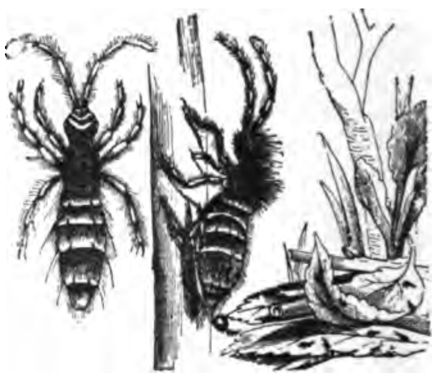
the abdomen, and one or two on the thorax; three ocelli are generally present on the head in addition to the fairly large faceted eyes; and the antennæ are composed of from seven to nine joints. The larvæ have a general resemblance to the adult insects, and in their last stage they remain inactive and take no nourishment. Less than a hundred species of Thysanoptera, belonging mostly to the European fauna, have been described. These little insects are frequently to be seen on flowers, and on other parts of plants. They feed upon the juices, and when present in large numbers are capable of doing an appreciable amount of injury. Some destroy the pollen grains, and so prevent the fertilization of the flowers. The corn thrips (*Thrips cerealium*) sucks the young grains on the ears of corn, and stops their further growth. *Heliothrips hæmorrhoidalis*, another species which we figure, is common in hothouses, where it may be found on the young buds of several different kinds of plants.

FEMALE CORN THRIPS
(Much enlarged.)

Heliothrips hæmorrhoidalis (greatly enlarged).

Order Thysanura

The Thysanura are active little insects, which live generally in obscure places and are mostly of too small a size to attract much attention. They never exhibit any trace of wings, undergo no metamorphosis, and have a distinctly segmented body, which is usually covered with hairs or scales and furnished behind either with a forked tail, used as a springing apparatus, or with two or three long, jointed appendages, which sometimes serve a similar purpose. Characterized on the whole by a somewhat primitive type of structure, and, in general appearance resembling the larvæ rather than the adult forms of other insects, the Thysanura are in some cases distinguished by special features of great interest. The springtails (Collembola) are all furnished on the under side of the first abdominal segment with a curious tube or sucker, from the mouth of which a glandular process, secreting a viscid matter, can be protruded; they are remarkable also from the fact that in most of them no trace of a tracheal system has yet been discovered. In the Collembola the eyes, when present, are in the form of simple or grouped ocelli; the antennæ number not more than six joints, and the abdomen has at most but six segments and very often only three. The forked tail,



Podura villosa.
(Natural size and greatly enlarged.)

which is attached to one of the hinder segments, is usually turned forward and held in position under the body; when released, it springs back, striking the surface of support, and causes the insect to bound up into the air. These little insects are to be found commonly enough under flower pots, leaves, and stones, or under the bark of trees and in other such situations. They may sometimes be seen collected together in great numbers, and spread over the surface of the ground like a layer of powder. Some species, such as *Podurca aquatica*, may frequently be seen floating in patches on pools of water, and by striking their tails against the surface of the water, they can spring up into the air just as readily as others do from the ground. *Desoria glacialis* is an interesting species, found in Alpine regions, where it is often to be met with on the surface of the ice. The bristle tails (Thysanura proper) form but a small number of genera, some of which are very remarkable in having a series of small rudimentary legs on each side of the abdomen in addition to the ordinary six legs borne by the thorax. In all the genera the antennæ are formed of a large number of joints; and the abdomen shows ten distinct segments, and, except in the genus *Japyx*, carries at the end two or three long jointed tails. *Japyx* has instead a pair of short pincers like an earwig. The little silver fish (*Lepisma saccharina*) is one of the best-known insects belonging to this suborder. Found very often in damp corners in houses, among old books or papers, it may be recognized by the silvery scales covering its body, and by its three bristle-like tails, of which the middle one is the longest. It feeds on the paste in the binding of books, and on sugary and starchy substances generally, though it is credited also with eating paper and linen. *Thermophila furnorum* is a species which lives in bakehouses, where, as its name implies, it is often found in the ovens.

Desoria glacialis.
(Greatly enlarged.)

Machilis is one of the genera in which the abdomen is provided with rudimentary legs in the form of small cylindrical appendages, each of which is accompanied by two small protrusible sac-like organs. An appendage similar to those on the abdomen is attached to each of the coxæ of the two hinder pairs of legs. The body, covered over with scales, is arched up in the middle, as in *Lepisma*, and carries three tails. The eyes are large and faceted; and the palpi are long, those of the maxillæ looking like a second pair of antennæ. Two species of this genus are found in Great Britain; one being common about rocks at the seaside, while the other is to be met with under stones in different parts of the country. *Campodea staphylinus*, the last insect we have to mention, is a pale, soft-bodied little creature, which is common almost everywhere under stones and in loose garden soil. It runs actively, and has two very long tails which it sticks up in the air or turns forward over its body. It has no eyes; the antennæ are shorter than the tails and of equal thickness throughout; and the abdomen has seven pairs of rudimentary appendages.

CHAPTER VI

JOINTED ANIMALS — *Continued*

CENTIPEDES, MILLIPEDES, SCORPIONS, AND SPIDERS — CLASSES
Chilopoda, Diplopoda, Arachnida, etc.

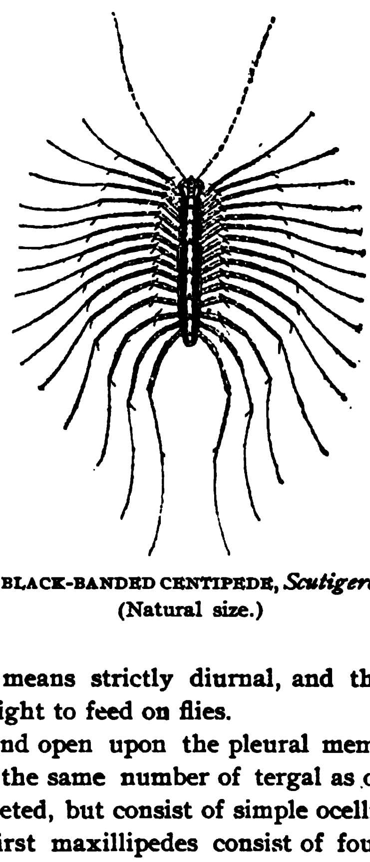
Characteristics of Centipedes

ACCORDING to modern views, centipedes are regarded as near allies of insects, the chief differences between the two groups being that whereas in the latter there are only three pairs of jaws attached to the lower surface of the head, in the former four pairs of appendages are modified to act as masticating organs. Moreover, the body of an insect is sharply divided into an anterior portion, or thorax, bearing three pairs of walking legs, and a posterior half, or abdomen, which in the adult at least is not provided with locomotor limbs, but the body of a centipede is composed of a large and varying number of segments, substantially alike in structure, and each bearing a single pair of legs. The number of segments varies from fifteen to considerably over one hundred, yet no matter how many pairs of legs there may be — whether it be fifteen or one hundred and twenty-one — their number is invariably odd.

The head bears a pair of elongate antennæ in front, and often eyes arranged in two clusters at the sides. On its lower surface may be seen the four pairs of jaws. The first pair, or mandibles, are two jointed and have a biting edge; the second pair, or maxillæ, are soft, leaf-like, and united together in the middle line, each consisting of an outer jointed and an inner unjointed branch. The third pair, known as the first maxillipedes, are composed of four or five segments, and much resemble one of the walking limbs, being tipped with a claw. The fourth pair, or second maxillipedes, are large, powerful, and project forward below the rest, so as more or less to conceal them from view. Their basal segments are usually fused to form a massive coxal plate, while the rest of the jaw consists of four segments, the terminal one being a long fang with a minute aperture at the tip, through which exudes poison secreted by a gland lodged inside the appendage. These two pairs of maxillipedes do not strictly belong to the head, since the dorsal elements of the segments that bear them are either distinct, or are united with the tergal plate of the following segment to constitute a massive basilar plate.

The rest of the body is composed of a varying number of segments, each consisting externally of a dorsal plate or tergum, and a ventral plate or sternum, connected laterally by a softer pleural membrane, to which the legs are articulated. These latter are usually short, composed of six or seven segments, and each is tipped with a single claw, and often furnished in addition with spines. The last pair are generally longer and stronger than the rest, and sometimes considerably modified in structure. Breathing is effected by tracheal tubes, which open by means of stigmata, placed almost always upon the pleural membrane of the segments.

Centipedes are divided into two subclasses—Anartiostigma, or those with unpaired dorsal stigmata, and Artiostigma, or those with paired lateral stigmata. In the former group, which contains the single family *Scutigeridæ* and the genus *Scutigera*, the head is furnished with a pair of large, compound, faceted eyes, the widely separated antennæ are exceedingly long and thread-like; and the body, although composed of fifteen segments, has only eight dorsal plates, all of which except the last are furnished in the middle of the hinder border with a single large respiratory stigma. The first pair of maxillipedes consists of five segments, and the coxæ of the second pair, or poison jaws, are not united; the legs are very long and their tarsi composed of a multitude of minute segments. The species of the genus *Scutigera* are distributed over all tropical and subtropical countries. Most are of small size, with the body only about an inch in length, but in India and China there are species (*S. longicornis* and *S. clunifera*) which may reach a length of several inches. The majority are vividly colored with black and yellow stripes or spots, and all are remarkable for their extreme agility, and the readiness with which, when handled, they part with their legs. None are indigenous to Britain, but the common South European *S. coleoptrata* has been introduced into a paper mill near Aberdeen, where, protected by the artificial heat, it has become established, and breeds. Unlike the rest of the centipedes, which habitually shun the light, the species of *Scutigera* may be seen in their native haunts darting about and catching insects regardless of the blazing sun. They are, however, by no means strictly diurnal, and the American *S. forceps* will come out in numbers at night to feed on flies.



BLACK-BANDED CENTIPEDE, *Scutigera*.
(Natural size.)

In the Artiostigma the stigmata are paired, and open upon the pleural membrane of all or some of the segments. There are the same number of tergal as of sternal plates; the eyes, when present, are not faceted, but consist of simple ocelli; the antennæ are stouter and not thread-like; the first maxillipedes consist of four segments, and the coxæ of the poison jaws are united. The subclass contains the orders Lithobiomorpha, Scolopendromorpha, and Geophilomorpha. The first of these approaches the Anartiostigma in many characteristics, particularly in being furnished with fifteen pairs of legs, the coxæ of which are of large size; and in one of the genera (*Cermatobius*), which forms by itself the family *Cermatobiidæ*, the tarsi of the legs are many jointed. There are either six or seven pairs of stigmata, situated upon the first, third, fifth, eighth, tenth, twelfth, and fourteenth leg-bearing segments in *Henicops* and *Cermatobius*, while those on the first have disappeared in *Lithobius*. In the latter genus, which with *Henicops* makes up the family *Lithobiidæ*, the eyes consist of a cluster of ocelli on each side of the head, while in

the other two there is only one pair of ocelli. Except in *Cermatobius*, the coxæ of the last five pairs of limbs are furnished with organs known as the coxal pores, which are the apertures of special glands.

The members of this order are found in all temperate and tropical regions, living often in pairs under stones, logs of wood, etc. The species of *Lithobius* are particularly abundant, and reach their largest size in the temperate parts of the Northern Hemisphere. A few only have been recorded from India and Australia, but none occur in Africa south of the Sahara, nor, with the single exception of a possibly introduced species in South America. In the Southern Hemisphere the genus is largely replaced by *Henicops*, which is represented in Europe and North America by a single small species, but has many larger forms in South Africa, Australia, New Zealand, and Chili. The single species of *Cermatobius* occurs in Halmahira, one of the Moluccas. There are about half a dozen species of *Lithobius* in the British Islands, one of the commonest and largest being *L. forficatus*, represented in the figure. Almost equally common and equally large, although seldom found close to houses, is *L. variegatus*,— a brightly-colored species with banded legs,— which is confined to the British and Channel Islands. The largest known species is the handsome *L. fasciatus*, measuring two inches in length, and occurring in many of the southern countries of Europe. In all cases the females — which may be recognized by the presence of a pair of dwarfed, claw-tipped appendages behind the last pair of legs — lay their sticky eggs one at a time, and roll them in the soil until they become coated with earth, and consequently protected from observation. The young, like those of *Scutigera*, are hatched from the egg with only seven pairs of legs, the remaining eight pairs being added during growth. The food of these centipedes consists of worms, insects, etc., which are killed by the poisonous bite of their destroyer.

COMMON ENGLISH CENTIPEDE.
(Natural size.)

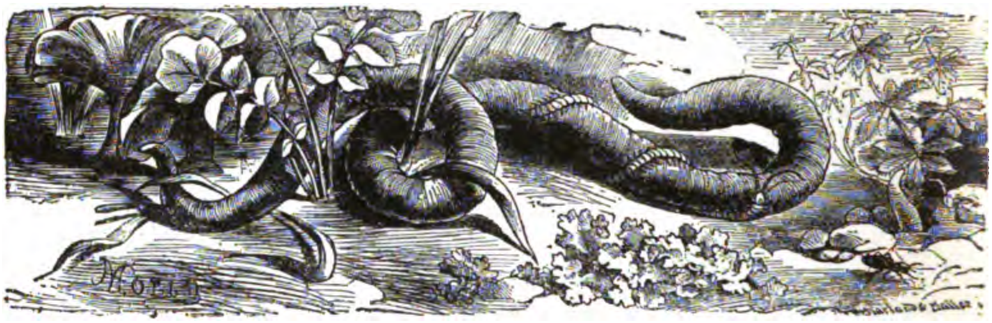
The second order, or Scolopendromorpha, contains the giants of the group, some of the tropical species of *Scolopendra* reaching a length of almost twelve inches. The legs vary in number from twenty-one to twenty-three pairs, and there are either nineteen pairs of stigmata, as in the aberrant genus *Plutonium* from Italy, or more usually nine or ten pairs situated upon the third, fifth, eighth (sometimes also the seventh), tenth, and alternate segments of even number. The eyes are either absent or consist of four ocelli on each side of the head, and the segments of the antennæ vary in number from seventeen to twenty-nine. The members of this order are referable to four families, the *Scolopendridæ*, *Scolopocryptopidæ*, *Newportiidæ*, and *Cryptopidæ*. Both the *Scolopocryptopidæ* and *Newportiidæ* have twenty-three pairs of legs, but in the latter, which is confined to the South-American region, the legs of the last pair are clawless and have their terminal segments many jointed and evidently functioning as antennæ, so that the centipedes may be

said to have a pair of feelers at each end of the body. The *Cryptopidæ* resemble the preceding in being blind, but have only twenty-one pairs of legs. They are all of small size, rarely exceeding an inch in length, and are spread all over the world, extending farther to the north than any other forms. One, namely, *Cryptops hortensis*, is by no means uncommon in England. The most important forms belong, however, to the *Scolopendridæ*, which in number of genera and species is far superior to the others. Like the *Cryptopidæ* they have twenty-one pairs of legs, but the tarsi of these appendages are bisegmented, and there are four eyes on each side of the head. From the shores of the Mediterranean in the west, and from China and Japan in the east, this family spreads southward over the entire Eastern Hemisphere, while in America it ranges from the Southern United States to Chili and Argentina. The larger members of the group are a foot in length, and very venomous, although their bite is seldom fatal to man. The *Scolopendridæ* live under stones and logs, and in the tropics frequently take refuge in bedding, boots, or clothes. Their food consists principally of cockroaches, beetles, worms, etc.; but they do not seem to be particular as to diet, since some have been found devouring lizards of larger size than themselves, and one kept for more than a year in the London Zoological Gardens was fed upon mice. The female lays her eggs in clusters like berries on the ground in some damp obscure place, and coiling herself round them remains immovable until the young are hatched and have gained strength enough to scatter in search of prey. When kept without food in captivity the mother will feed upon her young. The growth of these centipedes, and probably of all members of the group, is accompanied by the casting of the entire integument. The membrane at the back and sides of the head splits, the head plate turns forward, and through the aperture thus made the new centipede gradually struggles, leaving behind the old skin with its posterior segments retracted within those that lie in front like the pieces of a telescope. The genera of *Scolopendridæ* present a strong family likeness to each other; one of the most remarkable being the African *Alipes*, which has the last three segments of the last pair of legs flattened and leaf-like. The reason of this modification is unknown, but the creature is said to make a noise by knocking and rubbing its legs together.

CENTIPEDE (*Scolopendra morsitans*) DEVOURING A BEETLE LARVA. (Reduced.)

UPPER SURFACE OF HEAD OF *Geophilus tenuitarsus* (much enlarged).

The order Geophilomorpha, represented by the family *Geophilidæ*, includes the long worm-like centipedes, with the segments varying in number from thirty-nine to over a hundred. There are no eyes and the short thick antennæ are always composed of fourteen segments. Each segment of the body, with the exception of the first and last, bears a pair of stigmata and is double, an anterior portion being cut off by a distinct joint. The *Geophilidæ*, which are distributed all over the world, with the exception of the polar areas, are subterranean in their habits, burrowing after the manner of earthworms, upon which they almost wholly subsist. Two exceptions, however, to this rule must be mentioned, namely, *Linotænia maritima* and *Schendyla submarina*, both of which have been obtained upon the shores of Western Europe, beneath stones at low water mark. Although this is a strange habitat for animals, air-breathing species typically terrestrial can withstand immersion in sea water for many hours, and in fresh water from one to two weeks. Many of the species emit a phosphorescent fluid from glands opening upon the



GEOPHILUS GRAPPLING WITH EARTHWORM.
(Natural size.)

sternal surface of the segments. In Europe the time for the appearance of the phenomenon is between the end of September and the beginning of November. Although its import is not understood, it appears to be connected in some manner with the mating of the sexes. A small reddish species (*Linotænia crassipes*) is the one most commonly found exhibiting this phosphorescence in England.

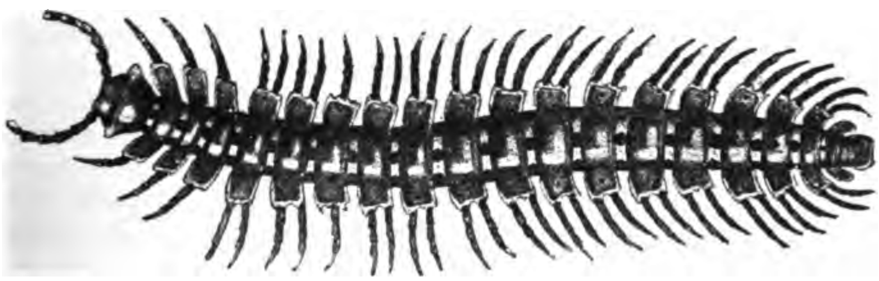
Remains of fossil centipedes referable to the existing groups occur in amber beds belonging to the middle portion of the Tertiary period; while mere aberrant types have been discovered in the Paleozoic rocks of the United States.

To a certain extent, connecting the centipedes with the millipedes and insects, is the class Symphyla, containing the single genus *Scolopendrella*. This is represented by minute pale-colored creatures, with long thread-like antennæ, fifteen or sixteen body segments, and twelve pair of legs, each of which is armed with two claws. It further differs from the centipedes in having only two pairs of jaws, as in the millipedes. *Scolopendrella*, which includes two British species, also occurs in North America, India, and Sumatra.

The Millipedes — Class **Diplopoda**

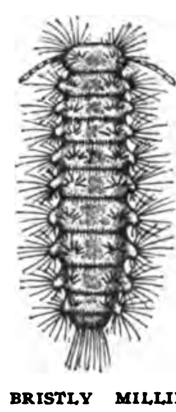
Although millipedes and centipedes were formerly united to form the class Myriopoda, it has been discovered that the characteristics in which they resemble

each other are comparatively trifling, and that the present group is much less closely related to the insects than are the centipedes. In addition to certain anatomical features, millipedes differ from centipedes in the following points: They have only two pairs of jaws, namely, the mandibles — which are usually three jointed — and the maxillæ, which unite to form a large plate or gnathochilarium, acting as a lower lip. Besides these two pairs of appendages, the head is furnished usually with two clusters of eyes, and always with a pair of short antennæ, never composed of more than eight segments, and usually of seven. The body consists as in the centipedes of a varying, often large, number of segments, some of which are furnished with two pairs of legs, and thus represent two primitive segments fused together. These segments are usually cylindrical in section, and although each



A SUMATRAN MILLIPEDE, *Platyrrhachus mirandus.*
(Natural size.)

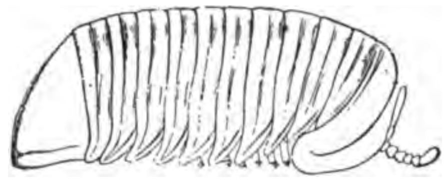
may consist of as many as five skeletal pieces, these are frequently fused together to form a single horny ring. The sternal surface, or the area between the bases of the legs, is generally reduced to a narrow strip, the legs being almost or quite in contact in the middle of the lower surface. The stigmata or breathing apertures are placed close to the base of the limbs on their outer side; and in addition to these apertures, there is often a pair of orifices in each segment (except the last and the first four) giving exit to an odorous fluid which serves as a protection to its possessors. The legs are short and generally composed of six segments, tipped with a single terminal claw. The last segment is devoid of appendages, and furnished with a pair of movable flaps or doors, closing over the hinder end of the alimentary canal.



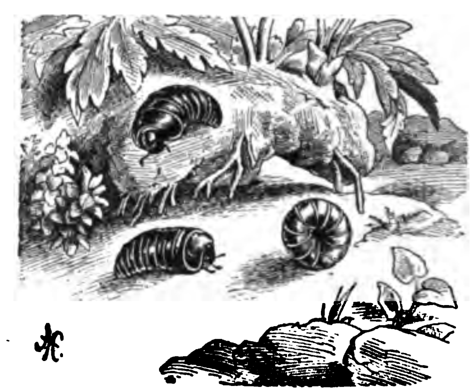
BRISTLY MILLIPEDE, *Polyxenus* (enlarged).

Millipedes are divided into two subclasses, Pselaphognatha and Chilognatha. The former, with the single family *Polyxenidæ*, contains minute, rather soft-bodied forms, only about one-tenth of an inch in length, in which the body is composed of nine segments and bears thirteen pairs of legs. The head and dorsal plates are furnished with transverse rows of remarkably formed somewhat scale-like hairs, and there is a great tuft of similar hairs upon the sides of each segment, while the last joint is furnished with a backwardly projecting tubular brush of straight bristles. The antennæ are eight jointed, and there are no thick glands. These minute creatures live beneath stones or the bark

of trees. A species of the typical *Polyxenus* is shown in the illustration. In the Chilognatha the antennæ are seven jointed, and the body is not furnished with tufts of scale-like hairs. The group is divisible into the orders Oniscomorpha, Limacomorpha, and Helminthomorpha. In the former, as represented by the pill millipedes, the body is short and broad, convex above and flat below, with the second and last segments enormously enlarged, and capable of being rolled up into a ball. The skeletal pieces which compose the segments are distinct and movably jointed together. Each typical segment consists of seven pieces; a large and vaulted tergum forming the upper surface and concealing the legs; while beneath this on each side there is a small pleural piece, and between this and the two legs two still smaller tracheal plates bearing the stigmata. The legs are in contact in the middle line of the body, and those of the last pair are enlarged in the male and transformed into a pair of clasping organs. Of the two families into which the order is divided the *Glomeridæ*, or small pill millipedes of Europe, have the antennæ close together upon the front of the head, the eyes with a single row of ocelli, and the body consists of only twelve segments. In the *Zephroniidæ*, or large tropical pill millipedes, the antennæ are situated on the sides of the head, the eyes are composed of a spherical cluster of ocelli, and the body consists of thirteen segments. In the South-African genus *Sphærotherium* the last pair of legs in the male is furnished with a well developed stridulating apparatus, consisting of a finely ridged plate, which by being rubbed against a set of granules on the inner surface of the last tergal shield, gives rise to an audible sound. Although no representatives occur in America, the order is spread over the Eastern Hemisphere, the *Glomeridæ* ranging over Europe and thence into India and Borneo, while the *Zephroniidæ* occur in South Africa, Madagascar, India, the Malay Peninsula, Australia, and New Zealand.



SUMATRAN PILL MILLIPEDE, *Sphæopæus*.
(Natural size.)



ENGLISH PILL MILLIPEDE.
(Natural size.)

The Limacomorpha, or slug-like millipedes, form a small group, containing but two known genera and three species included in the family *Glomeridesmidæ*. The body is composed of nineteen or twenty segments, all of them being approximately equal in size and similar in form, and none of them abruptly larger than the rest. The body is capable of being spirally coiled; its segments are formed much as in the Oniscomorpha, but the tracheal plates are not distinct. The last tergal plate, although small, forms a hood which covers over the last pair of legs, and these are modified in form as in the males of the Oniscomorpha. The rest of the legs are

composed of only six segments, the basal of which is much enlarged. There are no true eyes. *Glomeridesmus*, the typical genus, is known from two species, found respectively in New Granada and in St. Vincent; the other genus, *Zephroniodesmus*, occurring in Sumatra. None of the species exceed a quarter of an inch in length.

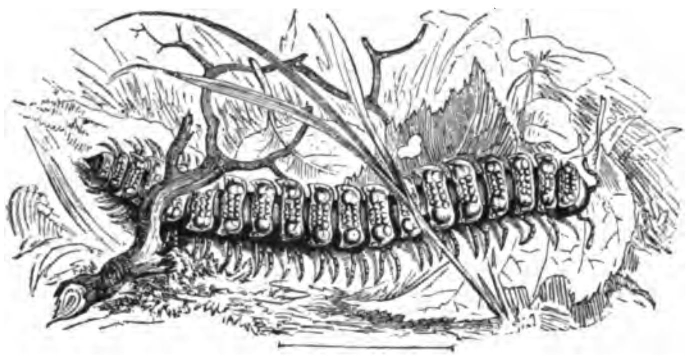
In the Helminthomorpha, or worm-like millipedes, which comprise the majority of the species, the body is composed of from nineteen to over ninety segments, is usually elongate and slender, and capable of being spirally coiled. The characteristics by which this group may be distinguished from the two preceding are that the last tergal plate forms a complete ring, inclosing the pair of valves and sternum, and that the tracheal plates take the form of two median sternal pieces, to which the legs are directly articulated. Moreover, the pleural scutes, although sometimes free, are less distinct than in the preceding groups. The order is divided into the suborders Colobognatha, Chordeumoidea, Callipodoidea, Iuloidea, and Polydesmoidea. In the first of these the mandibles have undergone great degeneration, and in the most modified forms (*Siphonophora*), the lower edge of the head (labrum) and the lower lip (gnathochilarium) are together produced into a long, piercing snout. The pedal laminæ, or sterna, are always free and movable, as are rarely the pleuræ. The secreting pores are present on all the segments, with the exception of the first four and the last; the parts of the segments around the pores being sometimes produced into wide plate- or rod-like processes covering the legs. The body segments vary in number from about thirty to over seventy, although the largest members of this group seldom exceed an inch in length, and are generally shorter. These millipedes occur in the tropical countries of both hemispheres, one form (*Polyzonium germanicum*) extending into Central Europe. In the Chordeumoidea there are no excretory pores, but each segment bears six symmetrically-arranged bristles. There are usually either thirty or thirty-two body segments; the pedal laminæ are always free, and often the tergal plate is keeled, or furnished with a large lateral process on each side. There is a pair of eyes on the head, and the jaws are normally developed.

MILLIPEDE, *Iulus sabulosus* (enlarged twice).

The Iuloidea, which is the largest suborder of the worm-like millipedes, contains families which may be distinguished from the last group by having the pedal laminæ united to the terga. Some of the tropical species reach six inches or more in length, and are the largest millipedes. Of the families, the *Spirostreptidæ* are spread over all tropical countries, but scarcely

migrate into temperate climes; while the *Iulidæ* reach their maximum development in Europe and the United States, and are only sparsely represented in the Tropics. The *Cambalidæ* are remarkable for the presence of crests and tubercles on their segments.

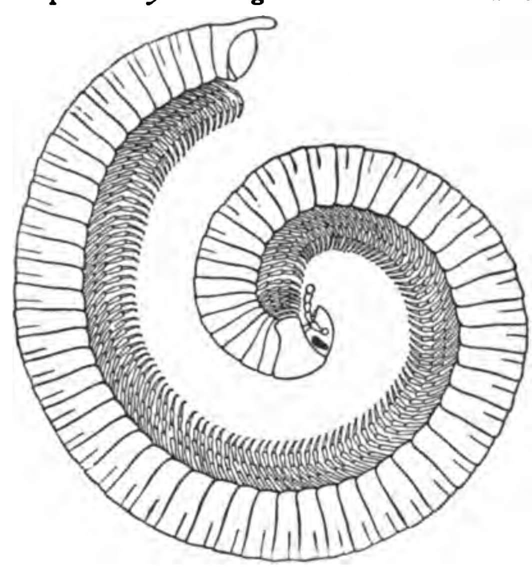
The suborder Polydesmoidea is almost as extensive as the Iuloidea, its members being spread over the habitable world. The largest species belonging to the genus *Platyrrhachus*, which reach a length of several inches, occur in tropical America and the East Indies. In all, the number of segments is nineteen or twenty, or the fewest among the Helminthomorpha. Eyes are wanting, and, as in the Iuloidea, the segments form solid rings, owing to the fusion of the pleuræ and pedal laminæ with the terga. Secreting pores are generally present on most of the segments, though sometimes absent in members of the family *Cryptodesmidæ*. When present, they are almost always borne upon large plate-like processes, springing from the sides of the segments. In distribution this suborder is cosmopolitan, the temperate forms being of small size, while some of the tropical species are large and beautifully colored.



FLAT MILLIPEDE, *Polydesmus complanatus* (much enlarged).

In habits all millipedes seem to be very similar. Although mostly vegetarians, feeding on soft roots, fruits, and succulent plants, one of the smaller kinds of *Iulidæ* eats worms and decaying animal matter. They occur under stones, logs of wood, or in rotten tree trunks in damp places; and in tropical countries come out in numbers after rain, when they may be seen crawling over the ground and climbing bushes. Moisture is necessary for their existence, and in captivity they freely drink water or milk. Most are slow in their movements, and never trust in speed to escape. When walking the body is kept fully extended, and propelled by the legs, the movements of which resemble a series of waves passing up the body from behind forward. As already stated, many forms are devoid of eyes; but even those possessing well-developed visual organs appear scarcely able to do more than distinguish light from darkness. As they crawl along, every inch of the road is first carefully touched by the antennæ, which are tipped with a sensory organ, and the creatures appear to be unaware of the presence of an obstacle until the antennæ have actually come into contact with it. All millipedes are perfectly harmless, and may be handled with impunity; but those species possessing odoriferous glands emit a disagreeable odor, due to the secretion of a fluid containing prussic acid. This, no doubt, serves as a protection against birds, ants, etc., to these otherwise defenseless creatures. Some birds will, however, eat them; and in a hornbill's nest in the British Museum the plaster used to block the entrance is largely composed of

crushed fragments of a large *Spirostreptus*. Many of the species which have no glands are otherwise protected. *Polyxenus*, for instance, is studded with bristles; while the Oniscomorpha roll themselves up into a round ball, with nothing but the horny integuments exposed. In the breeding season the females of several forms make earthen nests for their eggs, working the lumps together. The pill millipede (*Glomeris*) is said to incase only a few eggs in a ball of earth; while *Iulus* lays from sixty to a hundred in her nest before closing the aperture. Among the suctorial millipedes it is said that the common European *Polyzonium germanicum* coils round her cluster of eggs and stays by them until they are hatched. When hatched, the young are minute, pale-colored creatures, consisting of the head, with its antennæ and jaws, and six body segments, of which the first three are provided with a pair of legs apiece. During growth the rest of the segments are gradually added between the fifth and sixth, the latter remaining the terminal segment. Growth is also accompanied by molting.



MILLIPEDE OF THE GENUS *Spirostreptus*.
(From Celebes.)

Remains of extinct millipedes, referable to several of the existing families, occur in the middle Tertiary rocks, while one species of doubtful position has been discovered in the Cretaceous. In the Carboniferous and Devonian rocks a number of types apparently referable to the millipedes occur, although they have been assigned to a special order. From the existing forms they differ by the incompleteness of the union between the dorsal elements of each double segment.

Allied to the millipedes in many characteristics, but differing in certain special features, is the small group known as Pauropoda. These contain some minute creatures, found in earth and rubbish heaps in Europe and North America, and remarkable for the fact that their antennæ are branched at the apex, and furnished with long bristles. These have twelve body segments, and only nine pairs of legs, the first and the last two segments being limbless.

SCORPIONS, SPIDERS, TICKS, ETC.— Class **Arachnida**

The members of the three classes of Arthropods hitherto considered are characterized by the possession of a distinct head, bearing in front of the mouth a a pair of antennæ, and at the sides of the same at least two pairs of appendages, which act solely as jaws. In the scorpions, spiders, and their allies, on the other

hand, there is no such distinct head, while antennæ are wanting; the first pair of appendages being composed of two or three segments only, and acting as seizing or biting organs. These mandibles are, in fact, the only limbs that can be described as jaws. It is true that the basal segments of the second, and sometimes of the third and fourth, pairs of limbs are used for crushing prey; but their remaining segments nearly always form leg-like appendages, used both for locomotion and grasping. In scorpions, for instance, the limbs of the second pair are converted into large pincers; while in spiders they are short, and resemble the other limbs. In scorpions and the other groups, where these limbs form prehensile weapons, they are called *chelæ;* whereas in the spiders and ticks, where they are smaller and tactile in nature, they are known as *palpi.* Behind the palpi or chelæ come four pairs of limbs, acting as the locomotor organs. The palpi or chelæ are typically composed of six segments, and armed with a single claw, which, however, may be fused with the terminal segment, as in scorpions. The legs seem primarily to have been six jointed; and their segments, from base to apex, are respectively termed coxa, trochanter, femur, patella, tibia, tarsus. One or more of these is, however, almost invariably divided, so that the number rises to at least seven. Thus, whereas in the scorpions the tibia, and in spiders the tarsus, is divided, in other groups, like the Pedipalpi, the tarsus may be composed of a number of small segments. Accordingly, six pairs of large appendages are attached to the fore part of the body; and since this part was supposed to represent the combined head and thorax of insects, it is termed the cephalothorax. The abdomen may bear small, dwarfed limbs, as in scorpions and spiders, but its limbs are never, either structurally or functionally, like those of the cephalothorax. Although it may be undivided, this part never contains more than twelve segments, and often much fewer. Allowing twelve to the abdomen, and six to the cephalothorax, the body of the more typical members of the class comprises eighteen segments. All Arachnoids breathe air, either by means of short sacs or of long tracheal tubes communicating with the exterior by apertures (*stigmata*) on the lower surface of some of the abdominal segments. The young which, save in scorpions, are born in the egg stage, resemble their parents, and in the course of growth only undergo a series of molts without metamorphosis The class may be divided into eight orders, the first of which includes

THE SCORPIONS—Order SCORPIONES

In this group all the typical eighteen segments of the body are developed, although the last five are abruptly narrowed to form with the telson, or poison sting, the tail. The whole abdomen, including the tail, is distinctly jointed; but the cephalothorax is covered above with a single plate or carapace, bearing the eyes. The latter vary from six to ten, two being placed together in the middle, and the others arranged at the sides of the fore part of the carapace. Of the appendages, the four hinder pairs are similar, being tipped with a pair of claws, and used for locomotion. The two front pairs, however, have been transformed into pincers or nippers, the first pair, or mandibles, being small and three jointed, and the second,

the chelæ, or great pincers, of large size and six jointed. The coxæ of the four pairs of legs are immovably united to form the floor of the cephalothorax, and wedged in between those of the last two pairs there is a single sternal plate, the shape of which is of considerable value as a characteristic in the classification of these animals. The breathing organs consist of four pairs of sacs,—of which the cavities are filled up with a number of fine plates, arranged like the leaves of a book,—are placed upon the third, fourth, fifth, and sixth segments of the abdomen, and their apertures open upon the sternal or ventral plates of these segments. In addition to these stigmata, the abdomen bears a pair of curious organs called combs or pectines, which are placed upon the lower surface of the second segment, and are very characteristic of the group.

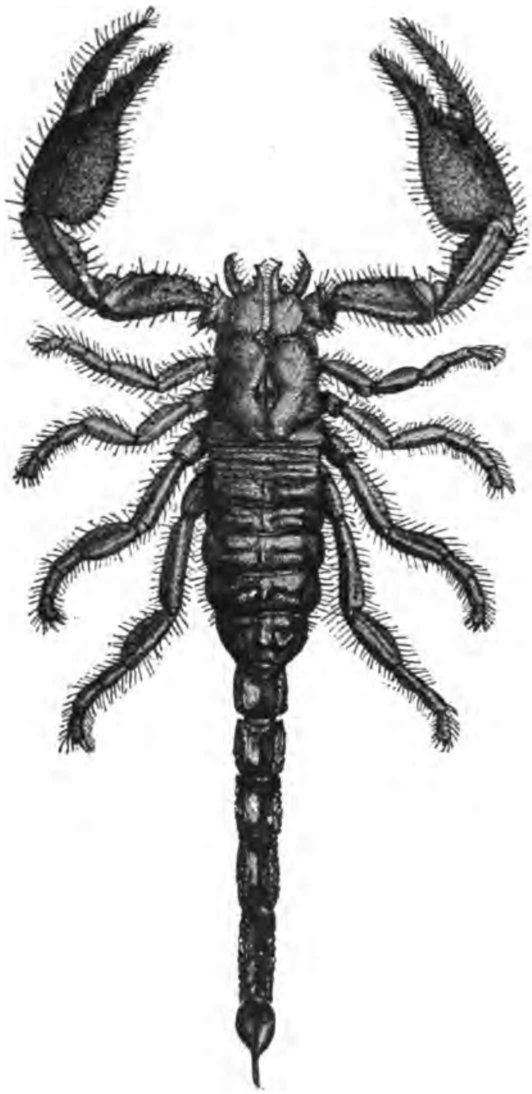
Scorpions are found almost all over the world to the south of the 40th or 45th parallel of north latitude, the only extensive area of land in the Southern Hemisphere in which they do not occur being New Zealand. The largest known forms occur in the tropical parts of Africa, especially on the shores of the Gulf of Guinea, and in the southern districts of India. These are the big black scorpions belonging to the genus *Scorpio*, which may attain a length of eight or nine inches, measured from the front of the head to the end of the tail. In structure the various species and genera are, on the whole, surprisingly uniform, all the known forms being referable to four families, namely, the *Buthidæ*, *Bothriuridæ*, *Iuridæ*, and *Scorpionidæ*. In the *Buthidæ* the sternum of the cephalothorax is small and triangularly pointed in front, in the *Bothriuridæ* it is transversely linear, and in the others it is broad and pentagonal; but while the *Iuridæ* agree with the other two families in possessing two spurs on the articular membrane of the tarsus, the *Scorpionidæ* have but one.

SPANISH YELLOW SCORPION,
Buthus europæus.
(Natural size.)
a. Lower surface of the abdomen, showing combs and stigmata.

Scorpions are a very ancient group, well-preserved remains of two genera having been discovered in the upper Silurian beds of both Europe and North America. In the Carboniferous period, too, they were evidently abundant; but no fossil forms have yet been discovered in rocks of Secondary age, and only one has been recorded from Tertiary strata, this having been discovered in the amber beds of the Baltic. The strangest fact, however, connected with fossil scorpions is the small amount of change the group has undergone, in spite of the enormous time that it has been in existence. For instance, the Tertiary species named *Tityus eocænus* does not differ in any important particulars from existing forms; while those from the Carboniferous can only be distinguished from them as a group by having the median eyes on the carapace in advance of the lateral. In this feature they agree with the Silurian species; but the latter, of which *Palæophonus* is the best known, are unique in the entire group in having the feet tipped with a single claw. For this reason the order,

including living and extinct species, has been divided into two sections, the Apoxypodes, or those with pointed feet, including the Silurian *Palæophonus*, and the Dionychopodes, or those in which the feet are tipped with a pair of movable claws. This last group is again divisible into the Anthracoscorpii, or scorpions of the Coal period, in which the median eyes are in front of the lateral, and the Neoscorpii, or recent forms, in which the median eyes are placed further back.

In habits the different species seem to vary but little, most of them being nocturnal and all of them exclusively carnivorous, feeding upon any living creature, weak enough to be overpowered. They seem, however, to be largely dependent upon chance for the capture of prey; for although provided with a large number of eyes, vision is so defective that they cannot see more than a few inches, and there is no evidence of the existence of any organs of hearing. The sense of touch, however, which resides in the hairs with which the body and limbs are studded, is exceedingly keen. No sooner does an unwary insect approach within reach than it is seized in the vice-like grip of the scorpion's pincers; then quick as lightning the tail is brought into use, and the sting plunged into the struggling prey, which, as a rule, quickly succumbs to the paralyzing effect of the poison. If, however, the prey be of large size, and muscular in proportion, the process of stinging is repeated; but it has been noticed that the scorpion in most cases carefully selects a soft spot into which to thrust its weapon, and does not strike at random. The object of this caution is evidently to avoid all risk of breaking the point of the sting against too hard a substance. The same care is shown in the carriage of the tail, this organ when not in use being almost always kept curled up in such a manner that the sting is securely protected. Having imperfectly developed visionary powers, and no tactile antennæ to supply this deficiency, scorpions



AFRICAN ROCK SCORPION, *Scorpio viatoris*.
(Natural size.)

when on the move always hold their large pincers well to the front, so as carefully to feel the way. But different species show considerable variation in the carriage of the body, some like *Buthus*, holding it high, while others shuffle along scarcely lifting it off the ground.

Again, many of the larger species, such as those belonging to *Scorpio* and *Opisthophthalmus*, live in deep holes, which they excavate in the ground by means of their large and powerful pincers. Others, like the little flat scorpions of South Europe (*Euscorpius*), hide away under stones and tree trunks, to which they cling belly uppermost; while others, like *Buthus*, dig shallow pits in sand, just deep enough to allow their eyes a clear vision of their surroundings, with the back on a level with the surface of the soil, and here concealed from view they lurk on the lookout for prey. Sound-producing organs have been found in the large, black rock scorpions of India and Africa; the organ, which lies between the basal segment of the pincers and that of the first pair of legs, consists of a set of tubercles and of a cluster of curved hair-tipped spines. When the scorpions are excited they wave their pincers up and down, and by thus scraping the spinules against the tubercles emit a rustling sound, which has been compared to that produced by rubbing a stiff toothbrush with one's finger nails. This organ is equally well developed in members of both sexes, and probably serves as a warning to enemies to keep their distance. An analogous organ is found in the South-African *Opisthophthalmus*, but in this case it consists of leaf-like hairs placed on the inner surface of the mandibles.

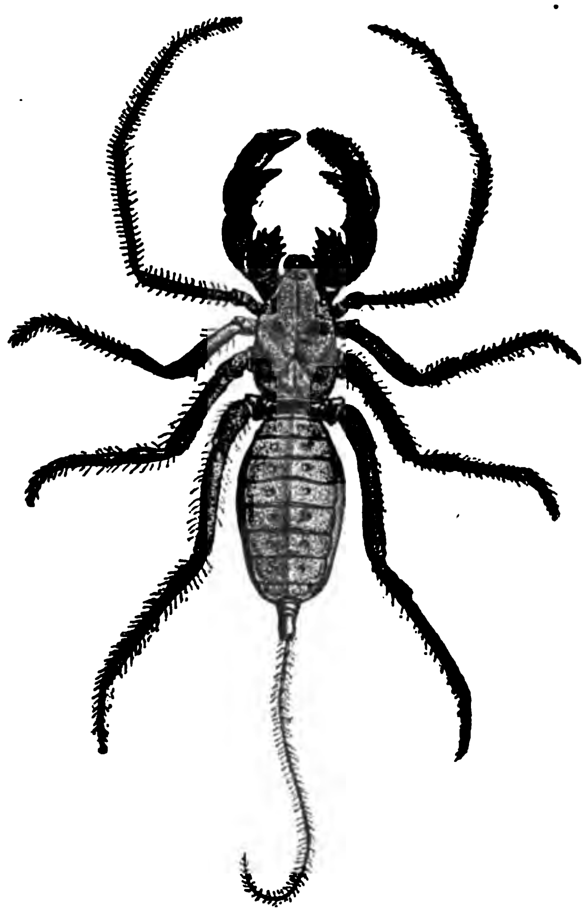
The Whip Scorpions and Their Allies—Order Pedipalpi

The members of the second order of the Arachnida resemble the scorpions in having the abdomen composed of twelve segments, and the second pair of appendages transformed into huge seizing organs, but differ from them in a number of important characteristics. The legs of the first pair, for instance, are not used for locomotion, but only as organs of touch, and have their last segment devoid of claws and divided into a series of secondary segments. Moreover, in the rest of the legs the feet are three jointed. The most marked distinctions are, however, found in the abdomen. In the first place, this region is sharply marked off from the cephalothorax by a deep constriction forming a narrow waist. There is no trace of combs, and the first sternal plate is of large size, and entirely covers the ventral region of the first and second segments; so that, although there are twelve dorsal plates on this region of the body, there are only eleven sternal plates. The breathing organs are of the same nature as those of the scorpions, namely, lung-books; but instead of forming four pairs, situated upon the third, fourth, fifth, and sixth sterna, there are only two pairs, of which the apertures are placed behind the sterna of the second and third segments. The order is divided into a tailed group (Uropygi), and a tailless group (Amblypygi). In the former the body is elongate, both cephalothorax and abdomen being much longer than wide; and to the last segment of the abdomen there is attached a movable tail corresponding to the

sting of the scorpions. On the lower side of the cephalothorax there are two distinct sternal pieces, an anterior and a posterior, the latter being triangular and lying between the coxæ of the last pair of legs, while the anterior is longer and placed between the coxæ of the first pair of legs and behind those of the pincers, which are united to form a kind of lower lip. The area between these sternal plates is narrow, membranous, and largely encroached upon by the coxæ of the second and third legs, which nearly or quite meet in the middle line. The legs of the first pair are also much shorter, and more typically leg-like than in the Amblypygi, the tarsal segment alone being divided into a series of nine cylindrical secondary segments.

Tailed Group

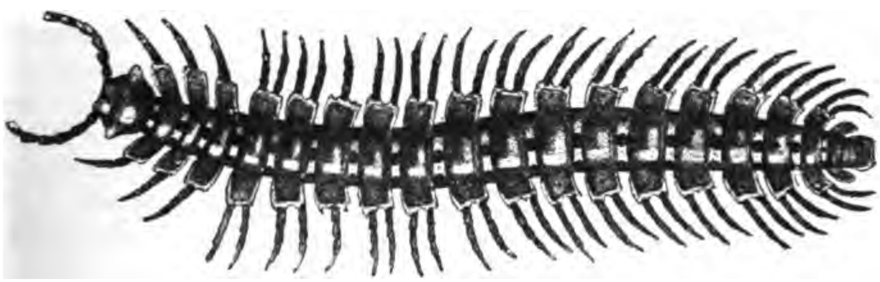
The tailed suborder may be further divided into the sections *Tartarides* and *Oxopœi*. The former is a small group in which the cephalothorax is divided into two regions by the jointing of the carapace, the region which corresponds to the posterior two pairs of legs having a small but distinct tergal plate of its own. Moreover, the eyes are either absent or reduced to a single pair, and the tailpiece, which is jointed to the last segment of the abdomen, is short and undivided. There is a single family of this tribe, the *Schizonotidæ*, so called on account of the jointing of the carapace. The family contains two genera, *Schizonotus* and *Tripeltis*, the species of which are pale-colored forms, less than a quarter of an inch in length, and confined to Burma and Ceylon.



FEMALE OF BORNEAN WHIP SCORPION, *Thelyphonus hosei*.
(Natural size.)

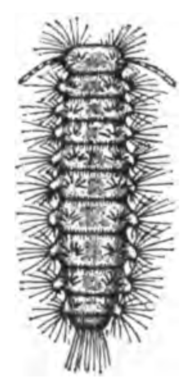
The term *Oxopœi*, or acid producers, is applied to the family *Thelyphonidæ*, or whip scorpions, which differ from the last in having the carapace undivided, and the tail long, thread-like, and many jointed. The last three segments of the abdomen, too, are very narrow, forming a movable stalk for the filiform tail, and on its last segment there are generally two, sometimes four, clear yellow spots, the *ommatoids*. The eyes are always well developed, two of them being situated close to the front edge of the carapace,

each other are comparatively trifling, and that the present group is much less closely related to the insects than are the centipedes. In addition to certain anatomical features, millipedes differ from centipedes in the following points: They have only two pairs of jaws, namely, the mandibles — which are usually three jointed — and the maxillæ, which unite to form a large plate or gnathochilarium, acting as a lower lip. Besides these two pairs of appendages, the head is furnished usually with two clusters of eyes, and always with a pair of short antennæ, never composed of more than eight segments, and usually of seven. The body consists as in the centipedes of a varying, often large, number of segments, some of which are furnished with two pairs of legs, and thus represent two primitive segments fused together. These segments are usually cylindrical in section, and although each



A SUMATRAN MILLIPEDE, *Platyrrhachus mirandus*.
(Natural size.)

may consist of as many as five skeletal pieces, these are frequently fused together to form a single horny ring. The sternal surface, or the area between the bases of the legs, is generally reduced to a narrow strip, the legs being almost or quite in contact in the middle of the lower surface. The stigmata or breathing apertures are placed close to the base of the limbs on their outer side; and in addition to these apertures, there is often a pair of orifices in each segment (except the last and the first four) giving exit to an odorous fluid which serves as a protection to its possessors. The legs are short and generally composed of six segments, tipped with a single terminal claw. The last segment is devoid of appendages, and furnished with a pair of movable flaps or doors, closing over the hinder end of the alimentary canal.



BRISTLY MILLIPEDE, *Polyxenus* (enlarged).

Millipedes are divided into two subclasses, Pselaphognatha and Chilognatha. The former, with the single family *Polyxenidæ*, contains minute, rather soft-bodied forms, only about one-tenth of an inch in length, in which the body is composed of nine segments and bears thirteen pairs of legs. The head and dorsal plates are furnished with transverse rows of remarkably formed somewhat scale-like hairs, and there is a great tuft of similar hairs upon the sides of each segment, while the last joint is furnished with a backwardly projecting tubular brush of straight bristles. The antennæ are eight jointed, and there are no thick glands. These minute creatures live beneath stones or the bark

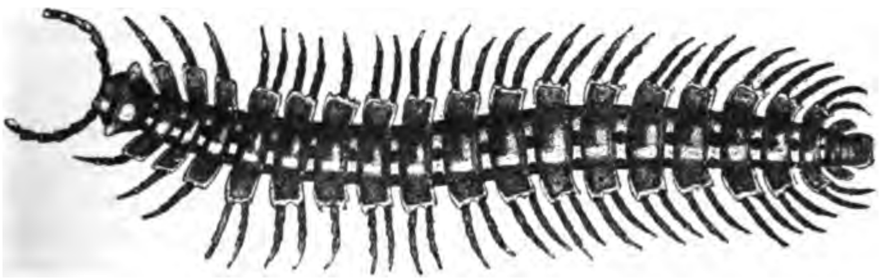
the great width of the carapace, we find the coxæ of the third and fourth pairs of legs widely separated, so that there is an oval sternal area, around which the coxæ of the five pairs of large cephalothoracic limbs are arranged radially. The anterior and posterior sternal pieces of the preceding suborder are present between the coxæ of the first and last pair of legs respectively, and the space between them is filled by horny pieces, varying in the degree of their development. The appendages also differ from those of the Uropygi, the basal segments of the pincers being freely movable and not united, while these appendages are longer, thinner, and very spiny. The terminal segment forms a sharp claw, closing back on the penultimate segment like the blade of a knife. The legs of the first pair are long and slender, and all its segments, except the first three, are converted into a long, thread-like, many-jointed lash acting as a feeler. The males do not, as a rule, differ strikingly in external characteristics from the females; although the abdomen is narrower, and the pincers and legs are longer.

In geographical distribution the group resembles the *Thelyphonidæ*, with the exception that it is spread over Africa south of the Sahara, extending from Senegambia and Abyssinia southward into Cape Colony; but there are no species from Madagascar. It also seems to extend in India farther to the west than do the *Thelyphonidæ*, since species occur at Bombay, and thence spread along the south coast of Arabia from Muscat to Aden. In the Indian region the species are not so numerous as the true whip scorpions, and in the Philippines they seem confined to caves, living permanently in the dark. None are known from Japan or China; but in America a few have been recorded from Texas and California, and many from Central America, the West Indies, and South America, as far down as Patagonia. Like the last, this group dates back to the Carboniferous, a single genus, *Græophonus*, having been described from the coal measures of North America. A single specimen has also been discovered in the Miocene gypsum beds of Aix. The existing forms may be all included in the family *Tarantulidæ;* the genera being mainly characterized by the degree of development of the horny pieces on the lower surface of the cephalothorax. In habits the group resembles the last, except that the species, instead of digging burrows, avail themselves of natural crevices and holes, hiding beneath stones or fallen tree trunks, for which they are adapted by the flatness of their bodies. The species frequenting grottoes in the Philippines cling to the walls, with legs extended, and dart into rocky fissures at the least disturbance.

Order Palpigradi

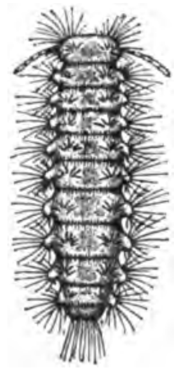
This group is represented only by a single South European form (*Kœnenia mirabilis*). Structurally, this minute creature occupies a position intermediate between the whip scorpions and the *Solifugæ*. As in the *Thelyphonidæ*, there is a long, jointed tail, articulated to the last abdominal segment, which with the two that precede it, is narrowed to form a movable stalk; but, as in the *Solifugæ*, the abdomen consists of only ten segments. The carapace is segmented and has no

each other are comparatively trifling, and that the present group is much less closely related to the insects than are the centipedes. In addition to certain anatomical features, millipedes differ from centipedes in the following points: They have only two pairs of jaws, namely, the mandibles — which are usually three jointed — and the maxillæ, which unite to form a large plate or gnathochilarium, acting as a lower lip. Besides these two pairs of appendages, the head is furnished usually with two clusters of eyes, and always with a pair of short antennæ, never composed of more than eight segments, and usually of seven. The body consists as in the centipedes of a varying, often large, number of segments, some of which are furnished with two pairs of legs, and thus represent two primitive segments fused together. These segments are usually cylindrical in section, and although each



A SUMATRAN MILLIPEDE, *Platyrrhachus mirandus*.
(Natural size.)

may consist of as many as five skeletal pieces, these are frequently fused together to form a single horny ring. The sternal surface, or the area between the bases of the legs, is generally reduced to a narrow strip, the legs being almost or quite in contact in the middle of the lower surface. The stigmata or breathing apertures are placed close to the base of the limbs on their outer side; and in addition to these apertures, there is often a pair of orifices in each segment (except the last and the first four) giving exit to an odorous fluid which serves as a protection to its possessors. The legs are short and generally composed of six segments, tipped with a single terminal claw. The last segment is devoid of appendages, and furnished with a pair of movable flaps or doors, closing over the hinder end of the alimentary canal.



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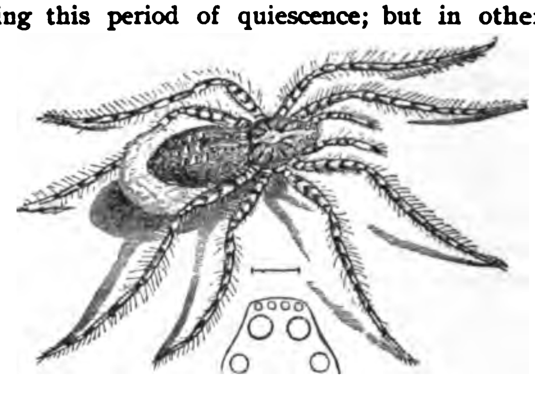
existing forms in having the abdomen protected above by a series of plates, as in the recent genus *Liphistius*, to which it was doubtless allied. In Tertiary times spiders closely related to those now existing were abundantly distributed over the Northern Hemisphere, as their well-preserved remains from the Oligocene amber beds of the Baltic and from the gypsum beds of Aix satisfactorily testify.

FEMALE OF *Drassus* LAYING HER EGGS.

The females of all spiders lay eggs, from which the young are subsequently hatched. The first act of the mother before laying, is to spin a small and often saucer-shaped web. In this the eggs are deposited, and are then covered over with two layers of silk forming a cocoon. The cocoons differ greatly in shape and color and texture, according to the spider that makes them. They may be green, yellow, white, mottled, or nearly black; round, oval, lenticular, or cigar shaped; soft and woolly, hard and nut-like, or smooth like parchment; while the outer casing is sometimes caked with earth or other foreign material for purposes of concealment. After the construction of the cocoon, the mother's interest in its fate varies in different spiders. Sometimes she pays no further attention to it, as in the case of the garden spider (*Araneus*), which suspends it in or near her web, and leaves the young to shift for themselves. In some cases, again, she remains for a longer or shorter time on guard in its vicinity, sometimes spinning a regular nest for her young and herself during this period of quiescence; but in other cases, especially among the wandering species, the mother carries the cocoon about with her, either attached to her spinners or clasped between her jaws. The young hatch inside the cocoon, and subsequently make their way to the outer world through a rupture in its walls. They appear in a helpless state, either clinging together in clusters, as in the *Argiopidæ;* staying in the nest, as in the jumping spiders; or clambering on to their mother's back, as in the wolf spiders. During growth the skin is periodically cast, the membrane of the cephalothorax splitting above the base of the limbs, and the carapace being raised to make an aperture, through which the body with the new skin emerges. The young spider is then soft, limp, and at the mercy of its enemies, until the integument becomes sufficiently hard and resisting to afford firm support to the muscles. Consequently, during this time, many species seek shelter in silken tubes spun for the purpose. On an average, perhaps, spiders undergo about eight or ten molts before reaching maturity, which is attained during the period intervening between the last molt and the last but one, so that the males and females, which during



FEMALE OF WOLF SPIDER (*Pardosa amentata*) CARRYING HER COCOON.

Below is shown the arrangement of the eyes when seen from above.

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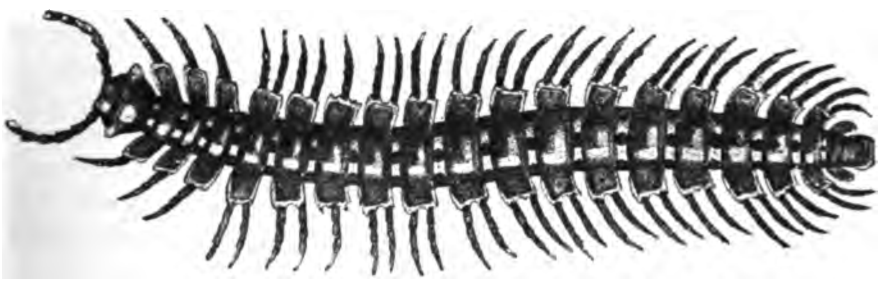

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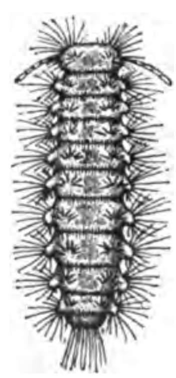

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the various kinds of nets became evolved. Another use to which the spinning of threads may be put is that of flying. This is especially practiced by young spiders, who on fine autumnal days climb to the tops of bushes and fences, and, raising the abdomen into the air, emit a thread or tuft of threads which blowing away in the wind soon become large and strong enough to carry the spider, sometimes to great heights above the ground. It was originally supposed that these threads were spun by a species called the gossamer spider, but it is now known that the habit is practiced by young spiders of different families. Floating about in the air, these fine threads meet and, becoming entangled, form masses of web, which ultimately fall upon the bushes and fields, sometimes covering them thickly with a white coating of fine silk.

Segmented Group — Suborder **Mesothelæ**

Spiders may be divided into the two main groups, *Mesothelæ* and *Opisthothelæ*. In the former, the spinning mammillæ, eight in number, are situated in a cluster in the middle of the lower surface of the abdomen; the upper surface of the latter being covered with a series of nine dorsal plates, resembling those of scorpions, while its lower surface is similarly furnished with two sternal plates covering the first and second pairs of lung sacs. In these characteristics the group differs from other spiders, and in having the abdomen segmented it constitutes a kind of link between them and the tailless Pedipalpi. It likewise resembles the latter in the structure and situation of the breathing organs, and also in the mode in which the mandibles are articulated to the cephalothorax; their basal segments being directed forward, parallel to each other and the long axis of the body, while the second segments or fangs are directed backward, also nearly parallel to the longitudinal axis. The eight eyes are situated on a tubercle close to the front edge of the flat and broad carapace; the median being small, and the lateral larger and placed in a semicircle on each side. The long and powerful legs are armed with spines, and tipped with three claws; their coxæ being long, whereas those of the palpi have no long maxillary process as in most other spiders. This group comprises only the family *Liphistiidæ*, with the genus *Liphistius*, of which there is one species from Penang, and another from Sumatra; both of large size, measuring about two inches in length. Nothing is known of their habits.

Typical Group — Suborder **Opisthothelæ**

In this group the abdomen is not segmented, and the spinning mammillæ — of which there are never more than six, owing to the disappearance or fusion of the inner branches of the first pair of appendages — have moved to the hinder extremity of the abdomen. It is separable into the sections *Mygalomorphæ* and *Arachnomorphæ*. The former group includes the forms making the nearest approach to the preceding suborder. The spinning mammillæ are reduced in number, being usually only four, owing to the disappearance of the anterior pair of appendages,

the posterior pair alone remaining, and being represented on each side by a long external jointed branch and a short inner one-jointed branch. Sometimes, however, two mammillæ of the front pair are retained. The eyes generally form a compact group but the lateral eyes on each side may be widely separated from the median pair.

Several families, passing almost imperceptibly into one another, are comprised in the group. Among these, the bird-catching spiders (*Theraphosidæ*) are the giants of the order. They include several genera, such as *Avicularia* and *Pœcilotheria;* a species of the latter being shown in the accompanying illustration. Usually they are dark brown or black in color, and clothed with short hairs mingled with

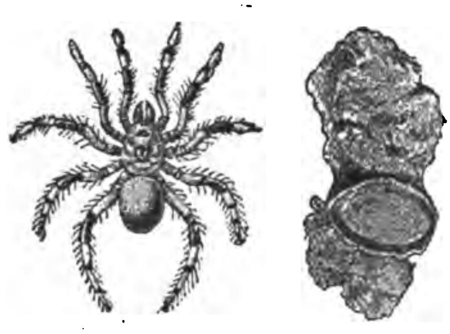
BANDED BIRD-EATING SPIDER (*Pœcilotheria fasciata*).

bristles. The lower surfaces of the feet are covered with a thick pad of silky hair, furnished with adhesive power, by means of which these spiders are able to climb vertical sheets of glass. The claws on the feet seem to be of but little service, being small and generally concealed among the hairs. There are a large number of species and genera distributed over all tropical and subtropical countries; the largest species occurring in the northern parts of South America, where specimens almost equalling a rat in size are met with. The males are always smaller than the females, being of lighter build, longer in the leg, and consequently more agile. These spiders spin no web for the capture of prey, living either in holes in the ground or beneath stones and silk-lined logs, or in silken tubes which they spin in

the hollows or upon the forked branches of trees. At night they issue forth in search of food which for the most part consists of beetles and other insects; but they will destroy and eat any living creature weak enough to be overpowered and travelers report having found small birds in their clutches. When laid, the eggs are wrapped in a strong cocoon, which the mother guards in her nest.

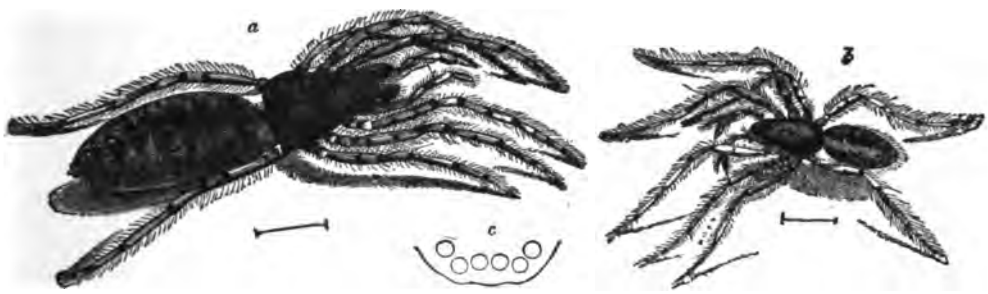
The bird-eating spiders inhabiting the countries lying between India and Queensland differ from those coming from Africa and America in possessing sound-producing organs, which lie between the outer surface of the mandible and the inner surface of the maxilla or basal segment of the palp. In one case, namely, in the subfamily *Selenocosmiinæ*, the outer surface of the mandible is furnished with spines, and the inner surface of the maxilla with a set of horny notes, of varying thickness and length, which are thrown into a state of vibration by being rubbed over the spikes on the mandible. This organ is equally well developed in both males and females, and appears in the young soon after they emerge from the eggs. When these spiders are irritated or alarmed, they raise themselves upon their hind-legs and, by waving the palpi, scrape the keys against the spines on the mandibles and produce a sound which has been described as resembling the dropping of shot upon a plate. It is probable that the sound thus produced acts for the benefit of the spider in warning other creatures. In the second group (*Ornithoctoninæ*) the notes, formed of feathery hairs, are situated on the outer surface of the mandible, and the spines on the inner surface of the maxilla.

Nearly allied is the family *Dipluridæ*, differing in having three well-developed claws upon the feet, and the external spinning mammillæ exceedingly long. Its members differ in habits, spinning upon the ground wide sheet-like webs to insnare prey. So far as the claw armature of the feet is concerned this family leads on to the trapdoor spiders (*Ctenizidæ*), famed for the perfection of their architecture. Although the species exhibit considerable variation in the perfection of their nests, the method of work appears in all cases to be substantially the same. A deep tunnel is first dug in the soil and then lined with silk to prevent the falling in of the loose earth. Then, with the object of excluding enemies such as ants and wasps, as well as to keep out rain, a lid, formed of layers of silk, strengthened with particles of soil, is built over the aperture, and attached along one side of the wall of the tube in such a manner that the elasticity of the silken hinge keeps the door normally closed. The outer surface of the door is then covered, if necessary, with fragments of moss, or with pieces of the plants that grow in the vicinity of the nest, so that when the door is closed it matches its surroundings and becomes practically invisible. In the genus *Nemesia*, from the shores of the Mediterranean and abundant in the Riviera, the lid is thin and light and of the so-called wafer type; but in the majority of cases it is thick and heavy, with a beveled edge, so that



PALM TRAPDOOR SPIDER (*Pseudidiops*) AND ITS NEST (natural size).

it fits tightly into the upper end of the burrow, and it is said to be of the cork type. Not unfrequently the spider digs a side gallery to this burrow, and shuts the aperture of communication between the two by means of a second door. Then, in cases of emergency, when the lid of the main entrance has been forced, the spider retreats along the second branch and closes the door, so that the enemy, after exploring the main tube and finding it empty, departs, believing the burrow to be tenantless. In some instances, indeed, the secondary branch is made to communicate by a special opening with the exterior, so that even if its internal aperture be discovered the spider can still beat a retreat. It is by no means, however, an easy matter to force open the lid in the first instance; for no sooner does the spider feel the attempt being made, than it seizes the inner side of the door with the claws of its front legs, and, firmly planting those of its hinder limbs in the silken walls of the burrow, resists every effort to force an entrance. A few species have forsaken the ground and taken to building their nests upon the trunks of trees, as shown in the opposite figure. Some of these, like the South-African *Moggridgea*, and the Mascarene *Myrtale*, avail themselves of natural irregularities in the surface and build silken tubes in the crevices; then, chipping off pieces of bark and lichen, cover the white silk, so that



FIELD SPIDERS (*Segestria senoculata*). *a.* Female; *b.* Male; *c.* Arrangement of eyes (enlarged).

the tube and its door become invisible. The South-American *Pseudidiops*, frequenting palm trees at Bahia, appears to excavate its own grooves in the bark by means of the fangs, and the stout, short spines with which its mandibles are armed.

In North Europe the only representative of this group is the genus *Atypus*, which has been found in England and Ireland. This genus belongs to the family *Atypidæ*, differing from the rest of the section in possessing long maxillary processes on the coxæ of the palp; and also in having six spinning mammillæ. Instead of making a trapdoor nest, this spider spins a long silk tube, closed at the ends, one half of which is buried in the earth, while the other lies loosely among the grass or stones on the surface of the ground. When a fly or beetle alights on this part of the web, the spider slowly and cautiously climbs to the spot, and, invisible all the time to the insect, suddenly seizes it from within, and tearing away the web drags its prey through the aperture, which is then repaired.

The next section is that of the *Arachnomorphæ*, which includes the common house and field spiders, and differs from the last in having the basal segment of the mandible vertical instead of horizontal, and the fang closing inward and backward. There are generally six spinning mammillæ, comprising an anterior two-

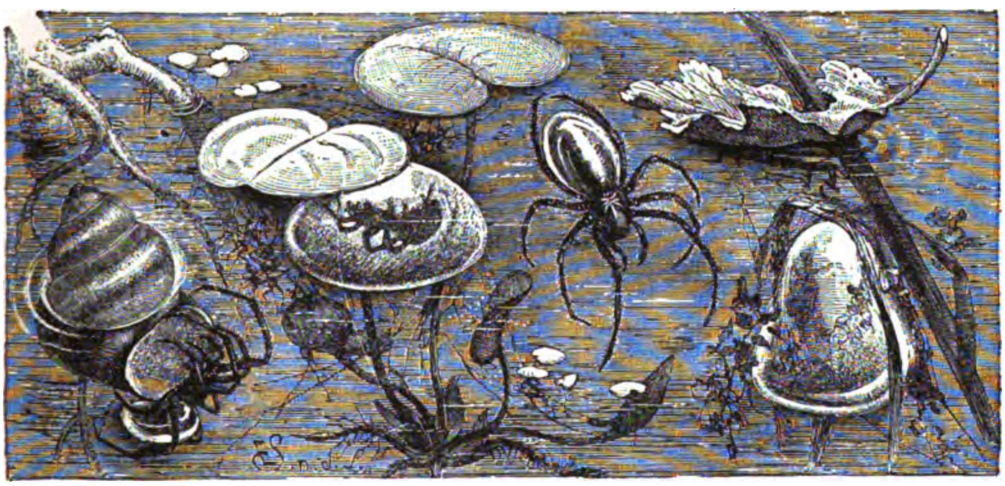
jointed pair, a similar posterior pair, and an intermediate single-jointed pair. Between those of the front pair there is either a functionless membranous piece, the *colulus*, or a paired plate, the *cribellum*, which is studded with the apertures of spinning glands. The eyes are occasionally arranged in three clusters, two being in the middle and three close together on each side; but usually the three lateral ones are scattered, and the eight eyes placed on the front of the head in two rows. The *Arachnomorphæ* are divided according to their structural characteristics and web-making instincts into a number of tribes each containing one or more families. The first tribe, *Umbellitelariæ*, contains the single family *Hypochilidæ*, represented by the genus *Hypochilus* in North America and *Ectatosticta* in China. These two spiders differ from all the rest in having the hinder pair of breathing organs in the form of lung sacs; the cribellum and calamistrum being present and the long and slender legs furnished with three claws. In the genus *Hypochilus*, which is found in the forests of Tennessee, the web is constructed beneath overhanging rocks and cliffs and has somewhat the form of an inverted saucer, made of thick white silk

HOUSE SPIDERS.
a. Male; *b.* Female (natural size); arrangement of eyes shown on left hand of figure.

and kept in place by a loose network of threads. Beneath this web the spider remains upside down, and it has the habit, common to other species, of violently shaking the web when alarmed. In the tribe *Pseudoterritelariæ*, as in the rest of the section, the breathing organs of the hinder pair are in the form of tubular tracheæ, but their apertures are widely separated and situated immediately behind those of the front pair. There is no cribellum nor calamistrum, and the eyes are reduced in number, being usually six, but sometimes, as in *Nops*, only two. Two well-known European representatives of this tribe constitute the genera *Dysdera* and *Segestria*. The former, found not uncommonly under stones in damp places, may be recognized by the coral-red color of its carapace, its bright yellow legs and pale gray abdomen. It makes no snare, merely constructing a small silken case, which serves as a protection to the mother and her eggs at the breeding season. *Segestria*, on the contrary, is much darker colored, with a band of diamond-shaped spots upon the upper side of the abdomen. It spins in holes in old walls a tubular nest, from whose aperture threads which serve to intercept prey pass to surrounding

objects. In addition to these forms — which belong to the family *Dysderidæ* — this tribe contains the family *Oonopidæ*, comprising small, slender-legged spiders, with a short and high carapace, and the exotic family *Caponiidæ*, the chief peculiarity of which is the transformation of the front pair of lung sacs into tubular tracheæ — a characteristic in which this family is unique among spiders. The *Filitelariæ* contain the family *Filistatidæ* and genus *Filistata;* the latter being represented by several species, none of which are British. They are small or medium-sized species, easily recognized by the aggregation of the eight eyes upon a tubercle placed near the front border of the carapace and of sedentary habits, spinning an extended web of white silk, in the form of an ill-defined tube.

To the *Tubitelariæ* are referred a number of families, presenting great variation both in structural features and instincts. The *Drassidæ*, for instance, spin no snare, but merely fabricate a silken case for themselves and young at the breeding season, while others, like the *Agalenidæ*, which include the house spider (*Tegenaria atrica*),



WATER SPIDERS, WITH NESTS (enlarged).

build a flat, sheet-like web, continuous at one extremity with a tubular retreat in which the spider lurks. The spiders of this last group which spin these sheet-like snares are furnished with three claws on each foot, and long posterior spinning mammillæ; whereas the *Drassidæ* and *Clubionidæ*, which live under stones, make no snare, and catch prey by chase or by lying in wait, have all the spinning mammillæ short, and only two claws on the feet. The above families differ from the preceding tribes of *Arachnomorphæ* in that the stigmata of the posterior pair of breathing organs are not only united in the middle line to form a single aperture, but this has also, as a rule, moved to the end of the abdomen in front of the spinning mammillæ. In two of the families, however, these apertures, although covered with a fold of the skin, are distinct from each other, and have only migrated part of the distance over the lower surface of the abdomen. These families, *Desidæ* and *Argyronetidæ*, have three-clawed feet like the *Agalenidæ*, but instead of being snare spinners, fabricate a silken case to serve as a receptacle for their eggs and as a place of refuge. Both have an aquatic mode of life. The first family is represented by the genus

Desis, found on the coasts and coral reefs of the South-African, Indo-Malayan, and Australian seas. At low water the reefs and rocks upon which they live are uncovered; but at the rising of the tide the spiders retreat into holes and crannies, where they surround themselves with a layer of silk strong enough to keep out water. They are good swimmers and feed upon small fish, crustaceans, etc. The *Argyronetidæ* live in fresh water, and are represented only by the water spider (*Argyroneta aquatica*), frequenting ponds and ditches in the British Islands and other parts of Europe. Among the waterweeds the water spider spins a thimble or bell-shaped web, the aperture of which opens downward. Then, ascending to the surface and thrusting its abdomen out of the water, it succeeds, by some process not clearly understood, in enveloping the hinder part of its body in a film or bubble of air. Retaining this bubble in position by means of its hinder pair of legs, the spider swims down to its web, and inserting its abdomen into the aperture of the bell, sets free the bubble of air, which rises to the upper part of the cavity of the web and replaces a certain quantity of water. The spider then fetches down another bubble, and repeats the process until the web is filled with air; it then has a water-tight chamber, in which it can dwell till all the oxygen is consumed. Here the eggs are laid and hatched. This spider lives on insects which it catches in the water. Belonging to the family *Agalenidæ* is the genus *Agalena*, of which a British species (*A. labyrinthica*) is abundant in most districts, and spins a large sheet-like web upon hedges and bushes. At its inner extremity the web ends in a tube communicating at the back with the bush, into which the spider makes its escape when pursued. This spider is exceedingly agile, running with great speed either on the ground or the upper side of its web. It has an ingenious method of overcoming insects like bees, with which it is afraid to come to close quarters, when they have fallen into the web. Attaching a thread to a spot close at hand, the spider runs in circles round and round its entangled prey, letting out the thread as it goes and gradually enveloping the insect, and effectually putting a stop to all struggles. Then, when it is tightly bound, the spider cautiously approaches, and, inflicting a bite upon the insect, puts an end to its life. Also belonging to this family is the so-called cardinal spider (*Tegenaria guyonii*), erroneously believed peculiar to the chapel at Hampton Court. Although none of the families of *Tubitelariæ* hitherto considered possess the cribellum and calamistrum, one family (*Amaurobiidæ*) is supplied with these organs. A well-known form is *Amaurobius similis*, which lives in holes in walls and ivy, where it spins an irregular, untidy, woolly web. The *Plagitelariæ* contain the family *Pholcidæ*, of which the genus *Pholcus* is the best known; one species (*P. phalangioides*) being not uncommon in the south of England, where in sheds and outhouses it spins a characteristic web, composed of a tangled mass of irregularly interlacing threads. This species has exceedingly long and slender legs, which at first sight give it a close resemblance to the harvest spiders. It moves slowly and clumsily; but when alarmed has a habit of hanging downward in the web, by the tips of the toes, and swinging the body round and round with such rapidity that it becomes almost invisible. No nest is made, and the cocoon consists of a flimsy network, enveloping the eggs, which the mother carries about in her mandibles.

The next tribe — (*Retitelariæ*) — contains a host of spiders belonging to the families *Theridiidæ* and *Linyphiidæ*, most of which are of small size, while some are the smallest of all spiders. In structure they approach very near those *Tubitelariæ* which have no cribellum. The web consists of an irregular network of lines, or a horizontal sheet of silk, but there is no tubular retreat; and the spider crawls along the under instead of the upper surface of the web. The cocoon is suspended in or near the snare, and no nest is built for its reception. Of the first family a well-known representative is *Lathrodectus tredecimguttatus*, which somewhat exceeds the common garden grass spider in size, and is either black or variegated with thirteen pale spots. Occurring in the countries bordering the Mediterranean, this spider spreads its webs over grass fields, and lives largely on grasshoppers. This species and others of the genus are much dreaded on account of their poisonous bite. The *Orbitelariæ*, or orb spinners, containing the best known of all spiders, are closely allied to the *Retitelariæ*, from which they differ by the presence of a smooth spot upon the base of the mandible, and also by having a narrow space between the eyes and the base of the mandible. In this group the art of net spinning has reached its highest point; all their claws on the feet being highly developed, while some of the hairs on the apex of the tarsi are barbed and toothed to form a kind of spurious claw. Such members of the tribe as possess a cribellum and calamistrum, belong to the family *Uloboridæ*, which contains the well-known European genera, *Uloborus* and *Hyptiotes*. Both these spiders are adepts at the art of concealment; the former spins a shabby orb web in a hollow tree trunk and places of a like nature, and leaves in its web the débris of insects that have been captured. It slings up, moreover, a string of cocoons, extending across the web, and at one extremity of the line, or among the dried carcasses of flies, the spider takes its stand and harmonizes so well in shape and color with its surroundings as to be practically indistinguishable among them. Even more interesting is *Hyptiotes*, which frequents pine trees, and is a small thick-set little species almost invisible on the bark. It spins a web, triangular in outline, with anchoring threads passing from each of the angles to surrounding objects, and the triangular space filled in with cross lines running parallel to the shortest side, and traversed in the middle by a single thread running from the apex to the base opposite. Taking up its position on the long anchoring thread which passes from the apical angle, and close to its point of attachment to the branch, the spider pulls in the thread so as to draw the whole net taut, coiling up the slack line between its front and hind-legs. The instant a fly strikes the net, the spider loosens its hold of the line, when the snare springs forward with

AN ORB SPINNER (*Tetragnatha extensa*) AT REST IN ITS SNARE. Arrangement of eyes shown above.

a jerk, still further entangling the prey by bringing other threads into contact with it. If necessary, the net is snapped more than once, and when the spider feels that the insect is enveloped, it crawls leisurely along the web to devour it. The genus is common to Europe and North America. The other members of this tribe belonging to the family *Argiopidæ* have no cribellum nor calamistrum. Their webs vary in form, but are mostly of the orb type, consisting of straight threads radiating from a centre to the foundation lines, which are stretched from one point of support to another, and of a spiral line passing from the centre to the circumference, affording support to the radial lines and partly filling in the spaces between them. The spiral line is the principal part of the web involved in the capture of insects, many of its strands being covered with a series of gummy drops like beads on a string, which greatly hamper the movements of a captured insect. The presence and position of an insect in the web is perceived solely by the delicate sense of touch in the spider's feet, and for this reason the spider either takes up its stand in the centre of the web, where its eight legs can command all the radii, or else beneath some leaf at the end of a long thread passing from the centre to its place of concealment. In cases of danger the spiders either drop to the ground by a thread, or, seizing the web with the tips of their feet, start spinning the body round and round in circles and causing the web to oscillate rapidly until it and its occupant almost disappear from view. The commonest British members of the family belong to the genus *Araneus*, of which the cross or garden spider (*A. diadema*) is so abundant in gardens late in summer and autumn. Some of the tropical forms, such as *Nephila*, are of enormous size, and construct huge webs strong enough, it is said, to arrest the flight of small birds. The males are veritable pygmies, as compared with the females. Also belonging to the family are those curious tropical spiders of the genus *Gastracantha*, which are protected from enemies by having the integument of the abdomen hard, horny, and armed with spines. The figure on p. 3197 of a species of *Tetragnatha* represents another tolerably common member of this family. It is characterized by its long and slender abdomen, and enormously strong projecting mandibles.

COMMON CROSS SPIDER, *Araneus diadema* (natural size).

We now come to spiders differing from nearly all the preceding in that they obtain their prey by hunting instead of constructing

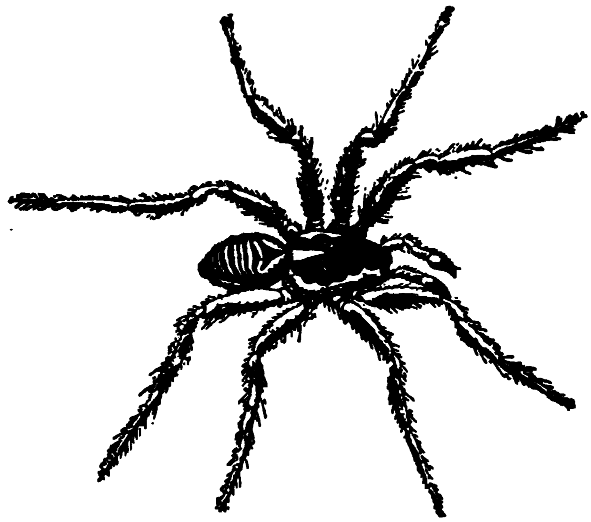
A SIDE WALKING SPIDER (*Xysticus viaticus*). Female, left-hand figure; male, right-hand figure (enlarged).

snares. The first tribe of these, the *Laterigradæ*, derives its name from the fact that its members walk with a side, crab-like gait, a power which they owe to the rotation of their legs backward in such a manner that the lower surface is turned forward and the front upward. The two first pairs of legs are longer and stronger than the others; the tarsi have but two claws, and the eyes are arranged in a double row. Of the families the so-called crab spiders (*Thomisidæ*) include small squat-looking forms, with the two hinder pairs of legs weaker than the two front pairs. The carapace is broad and often biangulate in front, and the abdomen frequently wider behind than in front. These spiders are mostly sluggish and noticeable for their protective coloration. Those frequenting flowers for the purpose of seizing the insects that visit them possess the power of changing their tints to suit that of the blossom in which they take up their abode. The egg cocoon is sometimes rolled in a leaf, sometimes left uncovered; but after constructing it the female forsakes her wandering life to watch over her offspring. The *Heteropodidæ* differ in having the mandibles more strongly toothed. The family is represented in Europe by a few spiders of medium size (*Sparassus*, *etc.*), but in the Tropics by many of large size. One of the best known is the tropical house spider (*Heteropoda venatoria*), a large, long-legged species, introduced almost all over the hotter parts of the world. The female carries her lenticular cocoon tucked to the lower surface of the cephalothorax. The annexed figure of a South-African spider (*Palystes*) shows the characteristic size and structure of the members of this family.

Passing over certain unimportant groups, we reach the running spiders, *Citigradæ*, which live on the ground, and capture prey by speed of foot. The legs are strong, not very unequal in length, and armed with three claws; the carapace is high, with the head compressed, and bearing on each side two pairs of large eyes belonging to the hinder row, and in front the four smaller eyes of the first row in a straight or curved line. The typical members of the tribe belong to the family *Lycosidæ*, or wolf spiders, of which a number of small forms are found in England, and the north and central parts of Europe. In summer these may be seen darting swiftly about among stones and grass, the female often carrying her cocoon attached to her spinning mammillæ. This cocoon is a spherical or more or less compressed sac, consisting of an upper and lower plate, fastened at the edges. The mother

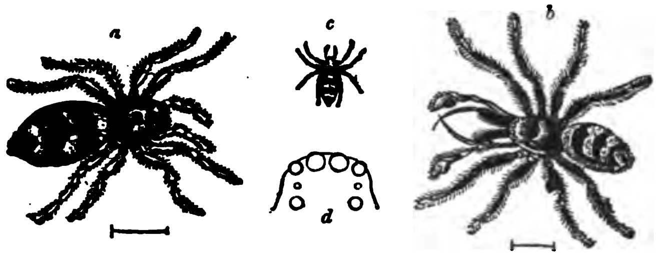
SOUTH-AFRICAN SIDE WALKING SPIDER, *Palystes*.
(Natural size.)

defends her packet of eggs with the utmost courage, and searches for it with diligence if lost. Soon after hatching, the young emerge from the cocoon, and climbing on to their mother's back cling there by means of silk threads, until strong enough to shift for themselves. The smaller species take refuge under stones or in crevices, and form no retreat; but many of the larger, especially those commonly known as Tarantula in South Europe, dig a burrow in the earth, lining it with silk, and in some cases building round the aperture a low circular wall of twigs or grass. To dig the burrow, the spider first loosens the earth with its mandibles, then gathering the pieces into a heap and sticking them together by means of silk and slimy matter secreted from the mouth, with a rapid flick jerks the pellet to some distance from the scene of its operations. At the entrance of the burrow the spider lurks on the lookout for passing insects, and during the winter covers up the aperture with silk and retires to the deeper parts to hibernate. In certain districts in the south of Europe these *Lycosidæ* are dreaded by the peasants, and fabulous accounts were given of the deleterious effects of their poison. The bite was said to be the cause of a disease of an epileptic nature called tarantism, and this could only be cured by music of certain kinds, which worked the sufferer up to a state of frenzy. Another family (*Pisauridæ*) differs in having the eyes of the front row separated by a wide space from the base of the mandibles. In this group *Pisaura mirabilis* is a common British spider, living in woods and fields, and at the breeding season constructing among grass or shrubs a large nest, open at the bottom. In this she lays her eggs, enveloping them in a thick cocoon which is carried about in her mandibles; but when the eggs are hatched, she retires to the nest and remains there with her young. The raft spider (*Dolomedes fimbriatus*) is a large and handsome species, frequenting the borders of lakes and marshes, and owing its name to its habit of constructing a raft of leaves upon which it floats on the surface of the water. It can run with speed upon the water, and does not hesitate to plunge beneath the surface or run along the submerged stems of aquatic plants in chase of prey. The mother carries her cocoon in her mandibles; but at the time of hatching fastens it to some plant near the edge of the water.


ITALIAN TARANTULA SPIDER, *Lycosa tarantula*.
(Natural size.)

The tribe *Saltigradæ*, or jumping spiders, contains the family *Attidæ*, all of which are of small or medium size, with a broad square head upon which the eyes are arranged somewhat as in the *Lycosidæ;* the anterior four being set in a

straight line upon the front of the face, while the middle pair are of enormous size. The legs are stout, rather short, and, a rare thing in spiders, the third leg is often the longest; there are only two claws, the place of the lower claw being occupied by hair tufts. For molting, hibernation, and egg laying, the jumping spiders spin a small saccular nest, which in the latter case is frequently open at one or both ends. In this the eggs are laid and hatched, and the young remain for some time under their mother's protection. Certain species depart from the normal type of structure of the others and closely resemble ants. This is brought about by the globular form of the abdomen, and a sharp constriction in the hinder half of the cephalothorax, so that the body appears to be divisible into three parts, as in an insect. Moreover, these spiders have learned to walk with the gait of an ant, holding up a pair of its legs to simulate the antennæ. Thus disguised, they live in the company of ants, and avoid the persecution to which they would be subjected if their identity were not concealed. Why the ants refrain from destroying them is unknown. These spiders spin no snare, and are dependent upon agility and great keenness of vision for the capture of prey. Sighting an insect at a distance, and eagerly watching the while its every movement, the spider gradually stalks nearer, until within reach of a leap; then, with a well-judged spring, launches itself on to its prey, and, in spite of vehement struggles, tenaciously retains its hold until the victim succumbs to the paralyzing effects of the poison. An Australian species (*Attus volans*) has acquired the power of prolonging its leaps into short flights, by elevating flaps of skin which arise from the abdomen.

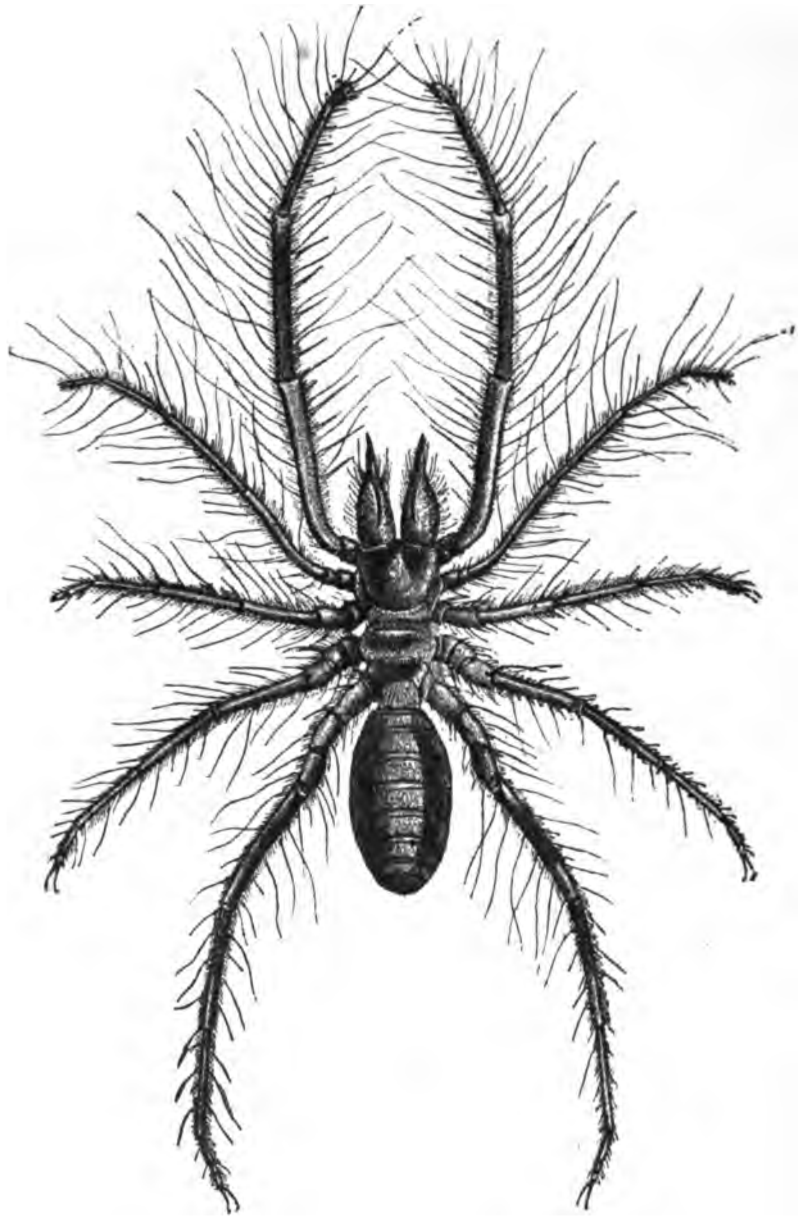


JUMPING SPIDERS (*Epiblemum scenicum*). *a.* Female; *b.* Male; *c.* Female (natural size); *d.* Arrangement of eyes.

THE FALSE SPIDERS — Order SOLIFUGÆ

The members of this group bear such a strong superficial resemblance to the true spiders that they are usually called by that name. The structural distinctions between the two orders are, however, so great and so easily ascertainable, that an example of the one may be without difficulty distinguished from an example of the other. In the first place, the abdomen is composed of ten distinct segments, and is not supplied with spinning glands, while the breathing organs, which are in the form of long tracheal tubes, open upon its second, third, and sometimes on its fourth sterna. The cephalothorax is distinctly jointed, its last two segments having separate tergal plates, while its front part is covered by a head shield bearing a pair of large eyes near the middle of its front border, and merely traces of the lateral eyes at the sides. The mandibles, which form a powerful pair of toothed nippers,

are articulated to the sides of the head plate. The appendages of the second pair are palpiform and tipped with a sensory organ; but their basal segments, like those



MALE OF PERSIAN FALSE SPIDER, *Galeodes.*
(Natural size.)

of the legs, are united on the lower surface of the cephalothorax, which has no sternum. The three posterior pairs of legs are tipped with two claws each,

but those of the first pair have only a single minute claw. On the basal segments of the last pair are certain racket-shaped organs, termed *malleoli;* and behind those of the second pair open a couple of large stigmata, leading into additional breathing tubes. The mouth is situated at the tip of a long horny beak, projecting forward between the mandibles. The males are smaller and lighter than the females, but have more powerful and longer legs and palpi. Their mandibles, however, are much weaker, and are furnished above with a sensory organ called the *flagellum.* In both sexes the mandibles are supplied on their inner adjacent surface with a set of ridges, which give rise to a grating sound when rubbed together. Both in Europe, Africa, and America, the *Solifugæ* closely follow the scorpions in their distribution, ranging in America from the Southern States of the Union southward into Chili, and being found over the whole of Africa; none, however, have been recorded from Madagascar. In Europe they occur in Spain, Greece, and South Russia, being abundant and of large size in the steppes of the latter country. Thence they spread southward and eastward over the desert countries of South-western Asia and India; but to the east of this point they become gradually scarcer, and although species have been discovered in Siam and the Moluccas, the group appears to be unrepresented in Australia and New Zealand. No extinct members have been described.

The order contains but a single family *Solpugidæ*, divisible into several well-marked genera, differing from each other in a number of structural characteristics. The largest members of the group belong to the genus *Solpuga*, confined to South Africa, and to *Galeodes*, which occurs in great numbers in Persia, Arabia, Egypt, and South Russia. Another well-known form is *Rhax*, having the same range as *Galeodes*, but being a smaller and shorter-legged type. In habits the false spiders are both diurnal and nocturnal; specimens of *Galeodes* and *Rhax* roam about deserts at night, and, attracted by the light, make their way into the tents of travelers, while at other times they may be met with darting about in the blazing mid-day sun. Most species of *Solpugidæ* are extremely active, running with great speed; but those of *Rhax* — which have enormous mandibles and short thick legs — are slow movers, and it is probable that the equally short-legged South-African *Hexisopus* is also relatively sluggish. When on the prowl, these creatures carry the body raised high on the posterior six legs, those of the first pair and the palpi being lifted up and waved in the air to feel the way, while the movements of the head from side to side bear witness to their eagerness to discover prey. Many stories are told of the courage and voracity of these animals. Their food seems to consist mostly of beetles and other insects; but they will not hesitate to attack such redoubtable adversaries as scorpions.

The False Scorpions — Order Pseudoscorpiones

The false scorpions are all of minute size, the largest not exceeding a quarter of an inch in length. They owe their name to the fact that, as in the true scorpions, the appendages of the second pair are of enormous size as compared with the body,

and form pincers; the mandibles being small, and also pincer-like, while all the legs are of the ordinary locomotor type. There is, moreover, no waist separating the thorax from the abdomen, and the latter is distinctly jointed. All these characteristics impart a considerable superficial likeness to scorpions, and formerly the two groups were looked upon as closely allied, although there are in reality many important, deep-seated differences between them. The abdomen, for instance, in the Pseudoscorpiones, is practically the same width throughout, none of the posterior segments being narrowed to form a tail, and the last bears no skeletal piece at all comparable to the scorpion's sting. The breathing organs in the false scorpions are structurally of the same nature as those of the *Solifugæ*, consisting of tracheal tubes, which open by two pairs of stigmata, situated upon the third and fourth abdominal segments. Like the true spiders, the false scorpions possess silk glands, but these are situated, not in the abdomen, but in the cephalothorax, and open by minute apertures at the tip of the movable fingers of the mandibles. In addition to these glands, there are others in the abdomen termed cement glands, which open upon the second and third sternal plates. The function of these is not known, but it has been suggested that they may secrete the gummy material which causes the eggs to adhere together. The eyes, either two or four in number, are placed on the sides of the fore part of the head region.


BOOK SCORPION, *Chelifer cancroides*. (Much enlarged.)

The false scorpions, which occur in all temperate and tropical countries, live for the most part under stones and the bark of trees, or hidden in moss or vegetable rubbish; only two European species, namely, *Chelifer cancroides* and *Chiridium museorum*, are commonly found in human dwellings, in dark corners and the wainscoting of rooms, in herbaria, or even in boxes of insect collections. Under these conditions the former is but rarely met with, but large numbers have been taken together in old beehives, wasp nests, and badly kept pigeon houses. The two species, however, are by no means found exclusively in habitats of this nature, both having been observed under the bark of trees, far from the abodes of men. In South America it is by no means uncommon to find species of *Chelifer* living beneath the elytra of the large longicorn beetles. Some species frequent caves and grottoes, and many of these, from dwelling permanently in the dark, have lost all trace of eyes. Lastly, there are others which occur exclusively upon the seashore. *Garypus littoralis*, for instance—the giant of the order, so far as Europe is concerned—being found in Spain and Corsica at the foot of the cliffs and beneath seaweed, while, on the south coast of England *Obisium maritimum* may be met with under the same conditions. The *Cheliferidæ* are, for the most part, slow in their movements, walking with the pincers extended to feel the way, although they also progress with facility sideways or backward. The *Obisiidæ*, on the contrary, are much more agile, darting backward with great speed when alarmed. Some species of the genus *Chithonius*, indeed, are said to possess leaping powers of no mean order.

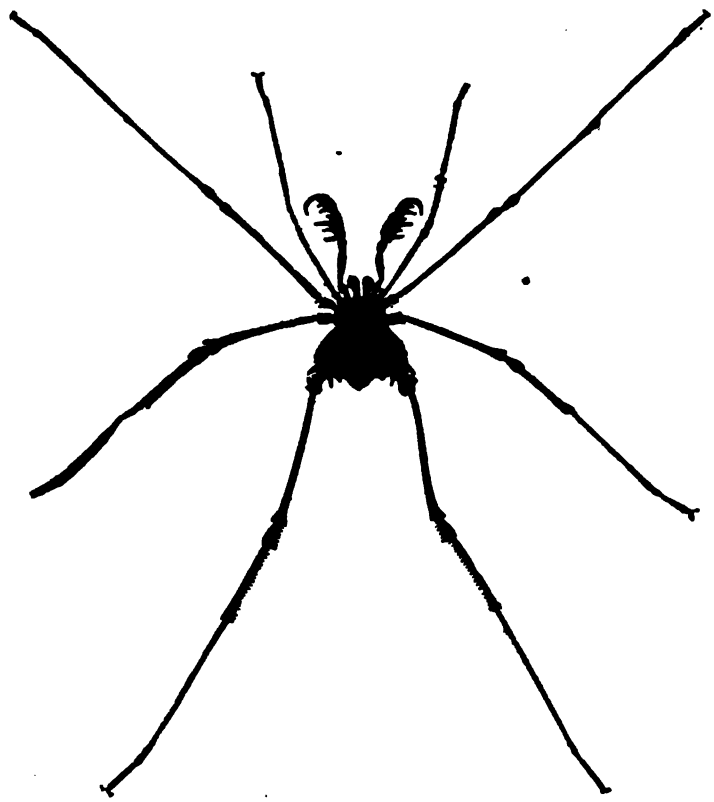
Although possessing silk glands, the false scorpions have not learned the art of insnaring prey after the manner of spiders. They merely use the silk for construct-

ing a small oval or spherical protective cell at the time of egg laying, or for purposes of hibernation, or molting. A species of *Chelifer* has been observed to build a cell, in the first instance, when preparing to molt, and in this receptacle it stayed for five days, until the new integument had acquired its normal strength. But about three months afterward it returned to the same quarters to spend the winter. As a rule these cells, or cocoons, are left uncovered, attached to the under sides of stones, etc., but the Alpine *Obisium jugorum* covers its case with pieces of earth and of vegetable débris. Like the majority of the class, false scorpions are oviparous; the number of eggs rarely exceeding fifty, although these are of relatively large size. By means of a gummy material, the eggs stick together into a rounded or oval mass, which remains adhering to the ventral surface of the abdomen of the female. The young stay with their parent until they have acquired their definite form, but, when first hatched, show no signs of segmentation, either of the body or limbs, and the abdomen, which is folded against the lower surface of the cephalothorax, bears rudiments of four pairs of appendages, which subsequently disappear. The only fossil remains of the group hitherto discovered occur in the Tertiary amber beds of the Baltic; the species being apparently generically identical with those existing at the present time.

THE HARVEST SPIDERS — Order OPILIONES

Although the members of this group are frequently compounded with the true spiders, yet, as in the case of the scorpions and false scorpions, the resemblances between the harvest spiders and the true spiders are comparatively few and superficial, while the distinctive characteristics are many and deep seated. In the first place, the body is oval, and the abdomen, which is united throughout its length with the cephalothorax, is, as in the scorpions and false scorpions, composed of from three to eight segments. The carapace which is short, unjointed, and usually bears one pair of eyes, is sometimes fused with the anterior segments of the abdomen; while in some cases the dorsal plates of all the abdominal segments are united to one another and to the carapace to form a single large plate, its separate elements being merely defined by shallow grooves. The lower surface of the carapace is either almost wholly covered by a forward prolongation of the sterna of the anterior abdominal segments, or by the ingrowth of the coxæ of the appendages. The mandibles are composed of three segments, and are always pincer-like, and sometimes very powerfully developed. The appendages of the second pair (maxilla and palpus) consist of six segments, and are never chelate, although in some species they are armed with spines, and the claw is much enlarged and capable of being folded back upon the tarsus. In these species the appendage is used as an organ of attack and defense. The four pairs of legs are alike in form and function, being used for locomotion. In addition to the mandibles and maxillæ, there are often accessory mouth parts, taking the form of masticating lobes on the maxillæ and the coxæ of the first and second pairs of legs; while above the mouth there is frequently a labrum, or upper lip, and above this a second piece, or clypeus. As

in false scorpions, breathing is effected by means of tracheal tubes, opening by a pair of orifices situated on the sternal plate of the abdomen, immediately behind the coxæ of the first pair of legs. In addition to these stigmata, there is one on each side of the cephalothorax lying below the edge of the carapace and above the coxæ of the first pair of legs. These were originally regarded as the apertures of breathing organs, but it is now known that they lead into glands, probably secreting an odorous and repellent fluid. In some species of harvest spiders, the males and females are almost exactly alike; but usually the two sexes are recognizable by sharply marked characteristics. In the males, for instance, the body is smaller and often more brightly colored, while the legs are both longer and more strongly spined, some of their segments being often modified in shape. The greatest modification, however, is found in the mandibles, which are often much enlarged; in the male of *Phalangium opilio*, for example, the second segment is produced upward into a great horn-like process. Fossil forms occur in the Carboniferous, one of which has been described as *Eophrynus*.

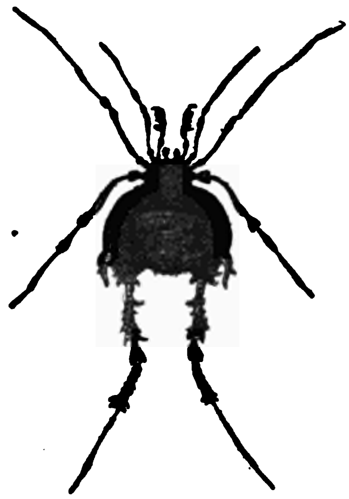


SOUTH-AMERICAN HARVEST SPIDER, *Gonyleptes spinipes*.
(Natural size.)

SUBORDER Laniatores

In the harvest spiders of this group the first sternal plates of the abdomen do not project forward to any great distance between the coxæ of the cephalothoracic limbs; the first being thus separated from the mouth by a long though narrow sternal area lying longitudinally between the coxæ of the right and left sides. The claw of the palpi is usually long, strong, and folded backward against the tarsus, while the other segments are generally furnished with strong spines. Only the

last four segments of the abdomen are free, the anterior coalescing with the carapace, which bears a pair of eyes, situated usually upon a single dorsal tubercle. This suborder is represented by numerous families in the tropical countries of both Eastern and Western Hemispheres. South of the Equator it extends to a considerable distance, reaching in South America as far as Tierra del Fuego; although in temperate lands to the north of the Equator it is poorly represented, there being only a few species of small size in Europe and the United States. In the tropical parts of Central and South America the group attains its maximum of development, both as regards species and genera, and the abundance and size of individuals. In the families *Cosmetidæ* and *Gonyleptidæ*, for instance specimens sometimes reach an inch in length, and cover with their long slender legs a span of many inches. The suborder also has representatives in South Africa and tropical Asia.



CHILIAN HARVEST SPIDER,
Gonyleptes chilensis.
(Natural size.)

An aberrant group of the Laniatores is the family *Sironidæ* containing a few species from South Europe and the Oriental countries. These are all of small size with elongate oval bodies, and relatively short and stout legs. The palpi, moreover, are not armed with spines, thus resembling those of the following suborder; and the legs are tipped with a single claw. The two eyes, which are situated at the sides of the carapace, are raised on stalks, and generally there is an additional eye on each side at the base of the stalk.

SUBORDER Palpatores

These harvest spiders differ from the preceding group in having the anterior sternal areas of the abdomen thrust far forward between the bases of the thoracic limbs, so as to lie just behind the mouth. The claw of the palpi is short and weak, and these appendages are small and unspined, being used merely as organs of touch and not of prehension. The legs, moreover, are furnished with a single claw. This group has a more extensive range than the last, being represented by a number of forms in Central and South Europe, and extending even to the Arctic Circle. The best-known family is the *Phalangiidæ*, which is exceedingly rich in genera and species, and appears to be almost cosmopolitan in distribution. The body is often soft skinned, small, and sometimes almost of the size and shape of a pea, while the legs, on the contrary, are exceedingly long and slender, and even thread-like. Still more curious are the members of the family *Trogulidæ*, in which the integument is hard and thick, while the legs are short and stout, and the front part of the head is produced forward on each side into a distinct plate, meeting its fellow of the opposite side to form a hood, hollowed out below, and concealing the jaws and mouth parts.

Group Ricinulei

Tacked on to the Opiliones is a small group termed Ricinulei, which differs in many important characteristics from the harvest spiders. The mandibles, for instance, consist of only two segments, and the palpi of only four (five with the maxilla). Moreover, the anterior part of the carapace is furnished with a movable hood, or *cucullus*, completely concealing the mouth; and the abdomen consists of only five segments. The legs are short, stout, and have two minute claws.

Considering the differences in structure presented by the various groups of Opiliones, it is not surprising that corresponding differences occur with respect to habits. The species with short, stout legs, and relatively heavy bodies, like *Trogulus* and *Stylocellus*, are very sluggish, *Trogulus* lifting its legs one at a time, and with apparent effort, and at the slightest danger ceasing all movement. This immobility, coupled with the protective covering of earth that adheres to its integument, conduces to the creature's safety by enabling it to escape observation. The Palpatores and Laniatores, with their long slender legs and light bodies, are much more active, and run off with speed when alarmed. Apart from the agility which it confers, the extreme length of limb possessed by these *Phalangiidæ* stands them in good stead by enabling them to stand on tiptoe and out of reach when threatened with destruction from armies of ants, which in tropical countries kill and devour every creature small enough to be overcome by numbers.

The Mites and Ticks — Order Acari

The mites and ticks constitute a group which, for diversity of structure, number of species and individuals, and minuteness of size, has no equal in the class. Many are wholly parasitic in habit, and have become so profoundly modified in organization, and their affinities with the rest of the Arachnida so masked by degeneration, that some authors have proposed to remove the Acari into a class by themselves. Nevertheless, most of the species which lead a free life and have departed least from the type of structure characteristic of the Arachnida, show so many points of resemblance to the Opiliones, that it is by no means easy to draw a hard-and-fast line between them. One leading characteristic, however, by which the ticks may be distinguished from the Opiliones is that the abdomen never presents any trace of segmentation; it is confluent with the cephalothorax, the fusion between the two being so complete, that, as in the harvest spiders of the group Palpatores, the anterior sternal plates of the abdomen are thrust far forward between the coxæ of the cephalothoracic limbs. As in all Arachnida, the mouth is adapted for sucking, but the jaws are often partially united, and form, with a plate termed the *epistome*, and the *labium* a beak. The epistome is often of large size, and is attached to the front border of the carapace; the mandibles are either pincer-like or simply pointed at the tip, forming piercing organs. The palpi, which resemble a pair of small legs, have their basal segments, or maxillæ, united together

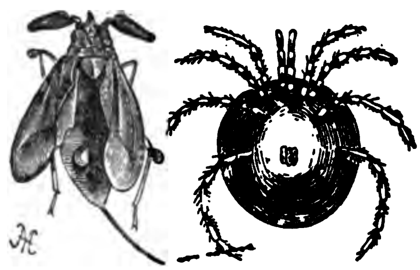
and to the labium, to form a conspicuous plate or *hypostome*, constituting the floor of the mouth. These organs forming the mouth parts are often separated from the rest of the cephalothorax by a membranous joint, and constitute a kind of movable head, the *capitulum*. In many cases there are no traces of special respiratory organs, breathing being effected by means of the skin; but, when present, such organs take the form of tracheal tubes, the apertures of which vary in position. They may, for instance, lie in the head between the mandibles and palpi, or far back in the body at the base of the legs of the last pair; but in some species they occupy intermediate positions, and open in front either of the first, second, or third legs. Another characteristic of some value in separating the ticks from the harvest spiders, is that in the former the young undergo a metamorphosis in the course of growth, being hatched from the egg as six-footed larvæ, which later acquire the fourth pair of legs. The order may be divided into the typical mites and ticks (Acarina). and an aberrant worm-like group (Vermiformia).

The Acarina include a number of families severally distinguished by the position of the respiratory stigmata, and the form of the mandibles and palpi. In the velvety mites (*Trombidiidæ*) the integument is soft and covered with variously colored hairs; the legs are adapted for walking or running, the mandibles are pointed at the tip, and the stigmata open in the anterior portion of the body. There is usually a pair of eyes on the carapace, although these may be wanting. These mites, which may be either parasitic or leading a free life, feed by sucking the juices of animals or plants. A fairly common British species is *Trombidium holosericeum*, the second name referring to the clothing of crimson silky hairs covering its body. In the six-footed larval stage these mites live parasitically upon harvest spiders, to which they cling, and resemble a cluster of bright red beads. Before attaining maturity they fall from their host to the ground, where, after undergoing their final molt, they lead a free wandering life, living upon minute insects such as aphides. In tropical countries mites of this genus reach a large size, measuring half an inch in length. They are beautiful and striking objects, resembling tufts of bright blood-red plush.

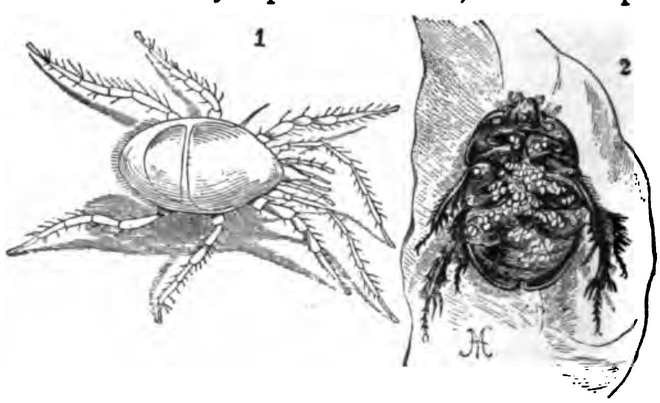
VELVETY MITE, *Trombidium holosericeum*, FROM BELOW (enlarged eight times; natural size on the leaf).

Nearly allied are the spinning mites (*Tetranychidæ*), which live exclusively upon plants, and obtain nourishment by sucking the sap. One of the best known is *Tetranychus telarius*, a little red mite, sometimes called the money spider. The web it spins is of very fine texture, and may usually be found on the backs of leaves, where it appears to be merely used as a protective screen for both adults and young. The silk is secreted from a conical nipple situated on the under side of the extremity of the abdomen, and, as in the case of spiders, is manipulated by the appendages. Also related to the *Trombidiidæ*, but connecting them with the next family, is the common mud mite, *Limnochares*, which lives in fresh-water ponds,

creeping upon the mud or the leaves of aquatic plants. The larva adheres to various water insects. The water mites (*Hydrachnidæ*) have been described as *Trombidiidæ* that have adopted an exclusively aquatic life. They live in fresh-water ponds and streams, where they may be seen swimming freely by means of vigorous strokes of their legs, which act like oars. In the adult the body is generally more or less spherical, and usually of a bright red or green color. The males of one species (*Atax globator*) have a curious blunt tail-like prolongation from the hinder end of the abdomen. The eggs are laid in the spring, in the stems of water plants which are perforated for the purpose, and the six-footed larvæ when hatched attach themselves to water bugs (*Nepa*), or water beetles (*Dytiscus*), by means of a large sucker on the front of the head. The abdomen then starts growing, the feet drop off, and the creature remains hanging like a sack to its host. One species (*Atax bonzi*) lives in the shell of the fresh-water mussel, while a few (*Pontarachna*) are marine. The next family (*Halacaridæ*) contains marine forms differing from the last in many important features; the mouth parts being more united. In addition to the pair of eyes on the carapace, there is an unpaired eye upon the epistome. These marine mites do not appear to swim like their fresh-water allies, but creep on the stems of seaweeds and zoophytes. They may be obtained either by dredging in deep water or in rocky pools upon the coast. Passing on to the family *Gamasidæ*, we find the stigmata placed far back in the body, frequently at the sides of the thorax, above the legs of the third or fourth pair. The beak is imperfectly developed, the palpi being foot-like and free, and the mandibles pincer-like. There are no eyes; and the legs are adapted for walking or running. The species figured (*Gamasus coleoptratorum*) may often be seen in numbers attached to the lower side of dor beetles. Others live parasitically upon bats and birds, one of the commonest being *Dermanyssus avium*, which infests poultry, canaries, and other cage birds, whence they sometimes migrate to the persons who have charge of them. Ceylon, Sumatra, and Mauritius are the habitat of *Holothyrus*, in which the body is hard and horny, like that of a beetle, and of a shining chestnut color.

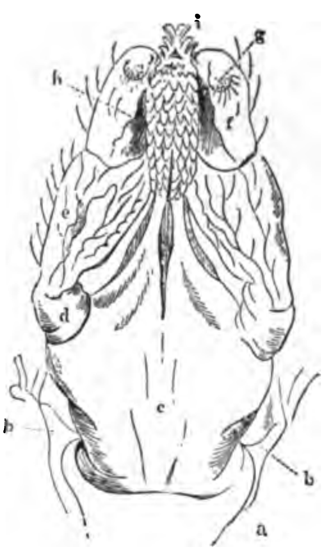


Right-hand figure, WATER MITE (*Atax spinipes*), SEEN FROM BELOW; Left-hand figure, WATER SCORPION, INFESTED WITH *Atax*.



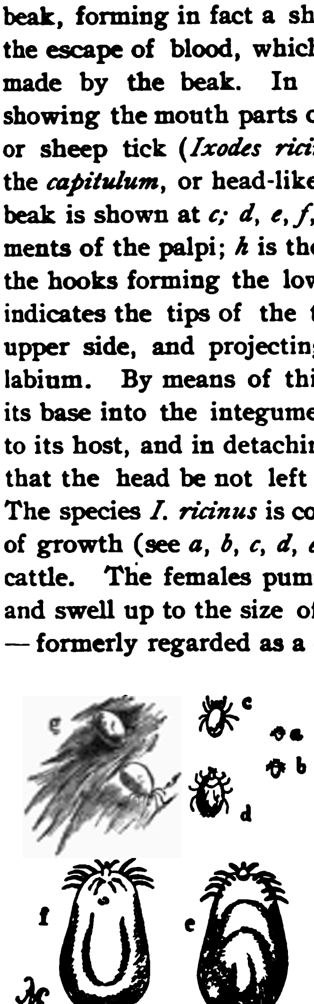
1. BEETLE MITE, *Gamasus coleoptratorum* (much enlarged); 2. DOR BEETLE, INFESTED WITH *Gamasus*.

Of all the Acari the best known and most troublesome are those belonging to the family *Ixodidæ*, which infest terrestrial vertebrates, and sometimes attach themselves to men. They are furnished with a longish, cylindrical beak, armed with recurved hooks, and formed by the two mandibles above and the long slender labium below. The palpi are either free, as in *Argas*, or closely applied to the beak, forming in fact a sheath for it, and preventing the escape of blood, which flows from the puncture made by the beak. In the accompanying figure, showing the mouth parts of the common English dog or sheep tick (*Ixodes ricinus*), the lower surface of the *capitulum*, or head-like process, which bears the beak is shown at *c; d, e, f, g*, represent the four segments of the palpi; *h* is the labial process armed with the hooks forming the lower side of the beak; and *i* indicates the tips of the two mandibles, forming its upper side, and projecting beyond the apex of the labium. By means of this beak, which is thrust to its base into the integument, the tick adheres firmly to its host, and in detaching them care must be taken that the head be not left behind buried in the skin. The species *I. ricinus* is commonly found in all stages of growth (see *a, b, c, d, e, f* of figure) adhering to cattle. The females pump themselves full of blood, and swell up to the size of a large pea; but the male — formerly regarded as a distinct species under the name *Reduvius* — is of smaller size, and resembles the empty female in shape. In distribution these pests are almost cosmopolitan, but in tropical countries they reach much greater dimensions than in temperate climes, the females sometimes attaining the size of a large gooseberry. In addition to mammals, they attack birds, tortoises, snakes, and lizards; and even the thick hide of the hippopotamus and rhinoceros is of no avail against attack. On account of their numbers, the effects they produce upon cattle are sometimes of a serious nature. These ticks are not, however, found exclusively upon their hosts; they also occur on the ground, and under stones, where pairing and the hatching of the eggs take place. When in want of food, both old and young climb the stalks of grass and shrubs, and clasping the tips of the leaves with their fore-limbs, stand with the other legs stretched out behind, ready to catch the hairy skin of cattle as they sweep through the herbage. Also belonging to this family are the genus *Argas* and its allies, the species of which nearly



MOUTH ORGANS OF SHEEP TICK.

c. Capitulum; *d, e, f, g.* Segments of palp; *i.* Spiny beak, formed by fused mandibles.



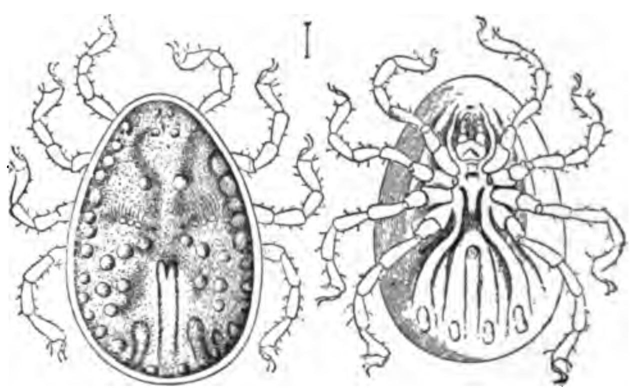
ENGLISH SHEEP TICK.

a. Six-legged young; *b.* Eight-legged young; *c.* Male; *d.* Female not distended; *e.* Female distended with blood from below; *f.* Same from above; *g.* Specimen clinging to the hairy integument of a mammal. (All figures enlarged twice.)

equal the larger Ixodes in size, and although much less numerous in species and individuals have almost as extended a distribution. They may be at once distinguished from the latter by their coarsely granular skin, flattish bodies, and the entire concealment of the capitulum beneath the projecting fore-margin of the cephalothorax. The species here figured (*Argas reflexus*) is habitually parasitic on pigeons, and occasionally occurs in England in places where these birds abound. A closely-allied form from Persia — where it is known as the poisonous bug of Miana — is much dreaded by the natives, its bite being said to produce convulsions, delirium, or even death.

DOG OR SHEEP TICK.
(Enlarged.)

The next family (*Oribatidæ*) — the members of which are sometimes called beetle mites, on account of their hard and horny integument — contains a number of species found for the most part under the bark of trees or in damp spots on the ground, where they live by sucking the juices of plants and minute animals. The palpi are free and tactile, the mandibles pincer-like, and the tracheæ, when present, open in the socket of the last pair of legs. The last family of true mites is that of the *Sarcoptidæ*, which are either free or parasitic. They have no special breathing organs; the palpi are basally fused to the rostrum, the mandibles are pincer-like, and the tarsi are often furnished at their tips with a sucker. The most familiar of those that are not parasitic are the species known as cheese mites (*Tyroglyphus*), which feed upon decaying organic matter. The common cheese mite (*T. siro*), which has the body armed with rows of long stiff bristles, is also found in flour and linseed meal. Another allied species (*T. entomophagus*) frequently causes much havoc among insect collections, entirely destroying the specimens if left unmolested, its presence in the cabinet being usually betrayed by the fine dust that results from its depredations. The most satisfactory method of destroying it seems to be soaking the cork of the box and the specimens with benzine. A large number of mites living parasitically upon mammals—such as the mouse mite (*Myocoptes*) — and birds also belong to the *Sarcoptidæ;* but the only species that we have space to mention is the itch mite (*Sarcoptes scabiei*), which gives rise to the disease known as scabies. This malady and the irritation accompanying it are caused by the mite excavating tunnels under



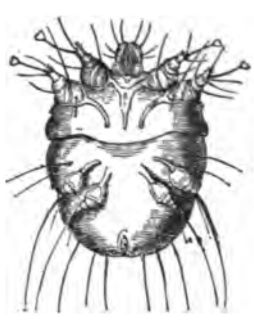
PIGEON TICK, FROM ABOVE AND BELOW (much enlarged).

CHEESE MITE.
(Much enlarged.)

the skin. In these the eggs are laid, and hatch; and the young then start burrowing on their own account. The burrows usually show as whitish lines on the surface of the skin, and if the skin at the end of one of these lines be pricked with a sharp needle, the mite may be without difficulty extracted.

Worm-Like Group

In the group Vermiformia the elongate abdomen is divided into a multitude of small rings. There are no eyes and no tracheæ. The suborder contain only the two families *Demodicidæ* and *Phytoptidæ*. In the former the adult is provided with four pairs of short three-jointed legs; the mandibles are styliform, and the palpi formed of four segments, each armed with a claw. The family is represented by *Demodex folliculorum*, a minute mite less than one-fiftieth of an inch in length, living parasitically in the sebaceous sacs and hair follicles of the human skin. The same or an allied species has been found in the skin of a dog suffering from mange, where they occurred in such quantities that thirty or forty might be seen in a single drop of matter. The members of the second family, commonly known as gall mites, have lost all trace of the third and fourth pairs of legs; the first and second pairs only remaining and projecting from the fore part of the body. These legs are long and five jointed, the mandibles are styliform, and the palpi tactile and united at the base. The long body is furnished with symmetrically arranged bristles. There are numbers of species, living exclusively upon the leaves of plants, to which they do much damage by the excrescences or galls they form. Each kind of tree seems to be infested by its own special gall mite, the so-called nail galls of the lime being caused by a species named *Phytoptus tiliæ*. These galls take the form of more or less cylindrical pointed columns, which stand erect on the upper side of the leaves. As a matter of fact, they seem to arise as an inpushing of the lower surface of the leaf to form a long pouch or pocket, in which the mites live. Galls of much the same structure, although differing somewhat in shape, occur in the sycamore, maple, elm, and various fruit trees. Other species, like the *Phytoptus* of the currant and the yew, attack the young buds and prevent them attaining maturity.



ITCH MITE (enlarged 80 times).
(Lower view of female.)

Demodex folliculorum (enlarged 600 times).

Aberrant Types

The mites and ticks complete the list of Arachnida; there remain, however, two small and obscure groups, which have been associated with the ticks, but apparently for no better reason than that their affinities are unknown. The first of these are the Tardigrada, or bear animalcules, which comprise microscopical animals living in damp sandy and mossy spots. The body is long and oval in shape, and possesses four pairs of bud-like unjointed appendages, each tipped with two claws. The last pair of legs projects from the extreme hinder end of the body. The mouth is situated at the opposite extremity, but the only trace of jaws that it presents is a pair of stylets. There appear to be no

organs of respiration or circulation; and, unlike what obtains in all true Arachnida, the sexes are united in each individual. The second group, Linguatulina or Pentastomida, is still less like the Arachnida. It includes internal parasites, which in form and mode of life present many points of resemblance to the intestinal worms. The body is long, broad in front, narrowed behind, and divided into a vast number of rings. Near the mouth there are two pairs of strong hooks, and although these are the only traces of appendages that the adult presents, the embryo is furnished in addition with two pairs of limbs, tipped with claws. It is mainly upon the evidence furnished by these limbs that the Linguatulina are regarded as degraded mites. One of the best-known forms is *Pentastomum tænioides*, which in the adult stage lives in the nasal passages of dogs and wolves. From these hosts the embryos escape to the outer world mixed up with the nasal mucus. Taken into the body along with the food of the hare or rabbit, they emerge from the egg, penetrate the walls of the intestine, and lodge themselves in the liver. Here they become encysted, grow, and go through a series of changes of form, accompanied by repeated ecdyses, until they pass into a state known as *Pentastomum denticulatum*. If the flesh of the rodent containing *P. denticulatum* be devoured by a dog, the parasite passes into the skull of the dog, gradually takes on the form of *P. tænioides*, and acquires sexual organs. Another species has been found living in the lungs of the Egyptian cobra, and a third in those of a species of boa.

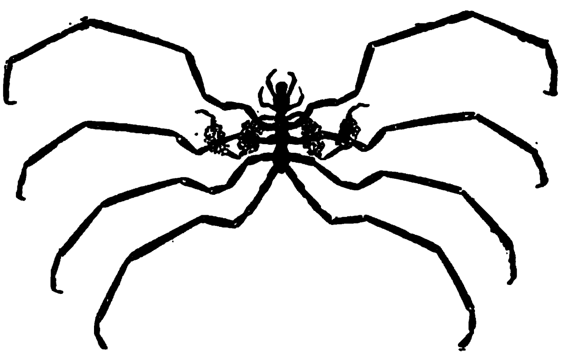
A SPIDER'S SPINNERETS (greatly magnified).

CHAPTER VII

THE JOINTED ANIMALS — *concluded*

THE SEA SPIDERS, KING CRABS, AND CRUSTACEANS — CLASSES **Pantopoda, Gigantostraca,** and **Crustacea**

THE animals belonging to the first of the three classes named above present such a marked general resemblance to the true spiders, that they have been included in the same class. On the other hand, from their marine mode of life, some writers have come to the conclusion that their affinities are rather with the Crustaceans. As a matter of fact, it appears impossible to affiliate them with either of these groups, and the general opinion is that they are entitled to form a class by themselves. In all these creatures the adult is provided with four pairs of well-developed legs, composed of a large and varying number of segments, and each tipped with a single claw. These limbs, which are often exceedingly long and slender, radiate from the sides of the cephalothorax, which is produced into stalks for their support. In front of these limbs, and attached to the headpiece, are sometimes three additional pairs of appendages. Hence the full complement of limbs is seven, and not six pairs as in the true spiders. The first pair of appendages, forming the mandibles, are short and often pincer-like; the second pair, or palpi, being also short; while the third pair, which are only developed in the females, are shorter than the true legs, and, from their function, are termed the egg-bearing legs. In some cases, however, these three pairs of appendages have entirely disappeared, as in the shore spider (*Pycnogonum littorale*). Projecting forward from the front end of the body is a long rigid beak, or proboscis, at the tip of which the mouth is situated. This beak is not formed by the fusion of limbs, like that of the ticks, but results from the great development of the area immediately around the mouth. The cephalothorax is divided into four distinct segments, of which the first, or head, supports the first four pairs of appendages, and has on its summit a pair of eyes, while the rest bear the three posterior pairs of limbs. Attached to the last of these segments, and projecting backward between the last pair of legs, is the abdomen, which is reduced to a mere tubercle or rod-like process. The greater



FEMALE OF SLENDER SEA SPIDER, WITH EGGS.
(Much enlarged.)

part of the body cavity is occupied by the stomach, which sends prolongations almost down to the extremities of the four pairs of walking legs. No breathing organs are known.

SHORE SPIDER (enlarged).

The sea spiders are exclusively marine, and range from shallow water to depths of sixteen hundred fathoms or more. The conditions of life in the deep sea have by no means a dwarfing effect upon them, since the species living in the abysses of the ocean attain a size never equalled by those frequenting the coast. Some of the former are of a very large size; *Colossendeis gigas*, for instance, covering a span of nearly two feet from toe to toe. None are able to swim, but all crawl slowly among the branches of seaweed. The embryo emerges from the egg as a larva, provided with a beak and three pairs of appendages, representing the short anterior three pairs of the adult; the four pairs of great locomotor limbs being subsequently produced by outgrowths from a posterior elongation of the body.

THE KING CRABS — Class **Gigantostraca**

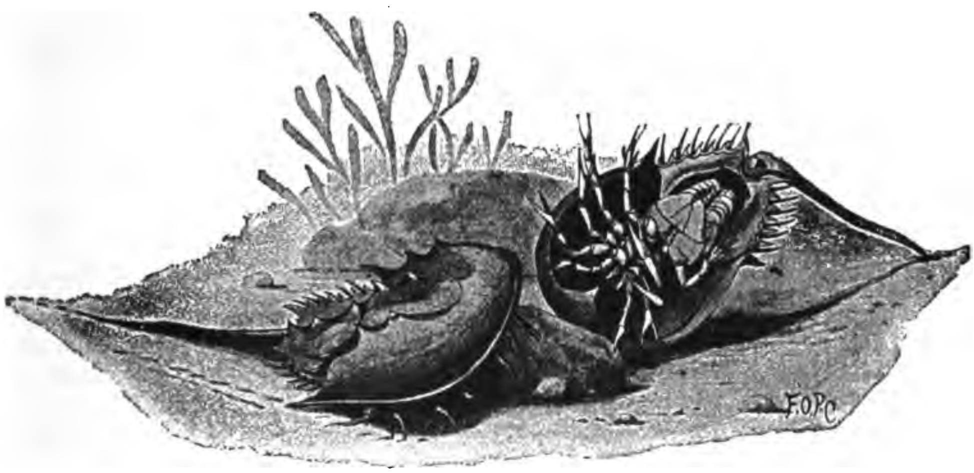
In many respects the representatives of this class occupy a position intermediate between the Scorpions and Spiders and the Crustaceans. From the fact that they are marine and breathe by means of gills, they were formerly always classified with the Crustaceans; but a large amount of evidence has been brought forward to show that whereas the earliest kinds are related to the primitive Crustaceans, the more specialized kinds are strikingly like some of the Scorpions. The class contains three orders, named Xiphosura, Merostomata, and Trilobita. The last two of these are now entirely extinct, and the first named nearly so, since it is represented at the present day by only a single genus, the king crabs or horseshoe crabs (*Limulus*).

Existing Forms

In the existing group, forming the order Xiphosura, the body is armed behind with a long spike-like tail, movably articulated to the middle of the hinder border of the abdomen. The abdomen consists of a large unsegmented pentagonal plate, armed on each side with six movable spines, and hollowed out below to receive six pairs of large flattened limbs, attached to the anterior part of its lower surface. With the exception of the first, each limb supports on its hinder surface a bunch of fine branchial plates, arranged one above another like the leaves of a book. In front of the abdomen comes the cephalothorax, which is covered above with an enormous carapace, having its border semicircular and its hinder angles acutely produced. The carapace is furnished above with four eyes, two being small and simple ocelli, situated close together some little distance behind the front border, while the others are large kidney-shaped compound eyes, placed at a corresponding distance from the lateral margin. The great size of the carapace is due to the prolongation of its edges into a wide sloping shelf-like expansion, concealing the walking limbs. Of the six pairs of the latter, the first are placed in front of the mouth, and are short, three-jointed nippers; while the rest are longer, generally six jointed, and all but the last nipper-like, the last or

sixth ending in a number of flattened plates. The basal segments of the second, third, fourth, and fifth limbs are furnished with large processes, projecting into the mouth and studded with numbers of slender softish spines. The mouth is thus situated between the bases of these limbs, near the middle of the lower surface of the cephalothorax. The males differ from the females in having the second, or second and third pairs of limbs thickened and otherwise modified. In the male of the round-tailed king crab (*Limulus rotundicauda*) the second and third pairs are considerably swollen, and the two fingers of the nippers cross each other when closed; whereas in the Moluccan king crab (*L. moluccanus*) the immovable fingers of these limbs are reduced to short processes.

In distribution, king crabs are limited to the east coast of the United States, to the shores of China and Japan, and of the Indo-Pacific islands, ranging from the Moluccas to Singapore and Java. In the last-named area two species, *L. moluccanus* and *L. rotundicauda*, occur. The Chinese species is known as *L. longispinus*, on



CHINESE KING CRAB.

account of the long and strong spines projecting from the carapace and abdomen; while the North-American species is *L. polyphemus*. The habits of the last-named species are tolerably well known. It spends the greater part of the year in water from two to six fathoms deep, and, being unable to swim, creeps about the bottom of the sea in search of food, or even lives buried in mud, into which it scoops its way. This it effects by thrusting the front edge of the carapace forward and downward into the mud, the tail behind being used as a prop, while the legs are engaged in raking up the mud and pushing it out sideways. The tail is also of service in helping the animal to regain its proper position if turned upside down. Digging the tip of the organ into the soil, the crab raises its body, and after a few efforts succeeds in struggling over. In fact, were it not for the possession of a long tail, the king crab would be as helpless on its back as a tortoise in the same position.

King crabs feed almost exclusively upon soft marine worms and bivalve mollusks. The food is seized and tucked into the mouth by means of the legs, where

the spines on the basal segments of these appendages crush and tear it to pieces. In May, June, and July, large numbers of king crabs approach the coast in couples to spawn. Choosing spring tides, they advance along the bottom until the water is shallow enough to allow the carapace to project above the surface. The female then scrapes a hollow in the mud, lays her eggs, and hurries back with her mate into deep water. By the action of the waves the eggs are soon covered with a layer of sand, and at ebb tide are exposed to the warmth of the sun. When first it emerges from the egg, the young king crab is a minute nearly spherical creature, with a fringe of stiff bristles running round the body, and differs from the parent in having no tail. Subsequently it undergoes a succession of molts, during which the form of the adult is gradually acquired, the tail appearing at the second change. The casting of the skin is effected by the splitting of the integument of the cephalothorax all round, immediately beneath the margin of the carapace. Through the aperture thus made the creature struggles forth, leaving its old shell behind. Before the growth of the tail the young king crab is in a helpless state, the slightest obstacle turning it upside down. In this emergency it starts a vigorous flapping of its gill plates, which cause it to rise in the water. Then ceasing the agitation, it at once descends with a chance of alighting right side up.

Extinct Types The existing king crabs are the typical representatives of the family *Limulidæ*, and fossil remains of *Limulus* occur in the Tertiary rocks as well as in the Cretaceous, Jurassic, and Triassic beds of the Secondary epoch. In the Paleozoic strata the class is represented by a number of forms, such as *Bellinurus* from the Carboniferous, *Protolimulus* from the Devonian, and *Hemiaspis* from the Silurian, which resemble *Limulus* in most of their characteristics, but differ in having the abdomen composed of at least nine distinct segments. On this account they are referred to a distinct family, *Hemiaspididæ*. It is, however, interesting to note that in the young king crab the abdomen is also composed of nine segments, so that just as in the life history of each individual king crab the final and adult stage with a solid abdomen is preceded by a transitory stage in which the abdomen is jointed, in the history of the class the existing and final stage, represented by the adult king crab of our own day, was preceded by a transitory stage, which, in the segmentation of the abdomen, was on a level with the young king crab.

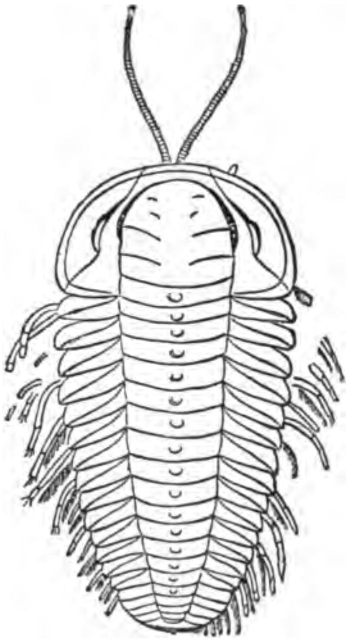
Merostomata The seas in which these fossil forms lived were also inhabited by some nearly allied types, differing from the king crabs, both in habits and some important points of structure. The carapace, for instance, was much smaller and did not conceal the legs, the last pair of which were generally thickened and flattened, and transformed, as in *Eurypterus*, into powerful short paddles. In one form, however, named *Slimonia*, the legs of the last two pairs were enormously elongated, evidently to serve the purpose of oars. The abdomen was used as a propeller, and it was long and divided into twelve flexible segments, the last of which bore the tail plate or telson. As in the king crab, the bases of most of the cephalothoracic limbs were armed with teeth and acted as jaws; but those of the anterior pair formed either short tactile organs or long and powerful nippers, as in *Pterygotus*.

The Merostomata, as these animals are termed, appear to have lived both in fresh and salt water, and their organization seems to show that they were powerful

swimmers; considering, too, the large size which some of the species attained, examples of *Pterygotus* reaching a length of from four to six feet, there is little doubt that these monstrous sea scorpions were the masters of the ocean in Paleozoic times.

Trilobites

A third order is represented by the extinct Trilobites or Trilobata, which swarmed in the seas of the Paleozoic epoch, and are among the earliest of known fossils. The name Trilobite, or three lobed, is given to them because in the best-known and typical members of the group the body is divisible into three distinct parts — and anterior cephalic shield corresponding to the head of the Crustacea and to the cephalothorax of *Limulus*, and formed, as in Crustaceans, of five fused segments; a median thoracic portion, composed of a variable number of freely movable segments; and the *pygidium*, also composed of a variable number of segments, but usually fused to form a great caudal shield. The lateral portions of the segments are produced sideways into great pleural plates, which mostly conceal the limbs, and the hinder angles of the cephalic shield are frequently prolonged into sharp spiniform processes, sometimes so long that they project backward beyond the hinder end of the body. On the upper side of the cephalic shield there are a pair of large kidney-shaped compound eyes, but no sign of the simple eyes present in the Xiphosura and Merostomata has been discovered. For many years no trace of limbs could be detected, but it is now known that a pair of limbs was attached to the lower surface of each of the segments of the head and body; though instead of there being two pairs situated in front of the mouth, as in Crustaceans, there was only one, as in the Xiphosura, Merostomata, and Arachnida. These, however, take the form of long filiform antennæ, and are placed on each side of a large upper lip or *labrum*, behind which comes the mouth. The rest of the appendages of the head, as well as those of the thorax, are alike, consisting of a large basal segment, from which spring two branches, an inner, which was used for crawling, and an outer, many jointed and fringed with bristles, which was perhaps used for swimming. The basal segments of these limbs in the head region were utilized as jaws, and in the pygidium the inner branches, or *endopodites*, were flattened and more or less leaf-like as in the lower Crustaceans, such as *Apus*. There is little doubt that Trilobites, instead of swimming in the open sea and leading an active predatory life, spent their time crawling or swimming slowly along the bottom, feeding upon worms, burrowing in the mud, and, in case of danger, rolling up tightly into a ball like wood lice. Many specimens are found fossilized in this condition, with the lower surface of the pygidium pressed against the head.



A TRILOBITE (*Triarthrus*). (From Beecher.)

CRABS, LOBSTERS, CRAWFISH, etc.— Class **Crustacea**

The Crustaceans comprise a large assemblage of Arthropods, presenting great diversity of structure. Some of the parasitic species have become so simplified in organization that they appear to present no relationship with the higher members of the class, such as crabs, lobsters, wood lice, etc. Yet it is certain that all the species, whether terrestrial or aquatic, free-living, sessile, or parasitic, belong to the same stock, and may be derived from the same fundamental plan of structure. Essentially the body consists of a large number of segments, to each of which is attached a pair of two-branched appendages, the external branch being called the exopodite and the internal the endopodite. Five segments at the front end of the body unite to form a head; the appendages of the first two of these segments being situated in front of the mouth, and performing the office of feelers or antennæ, while those of the remaining three segments are transformed into jaws, the first pair of jaws being the mandibles and the following two pairs the maxillæ. The rest of the appendages are variously modified, and to some are attached respiratory organs in the form of gills. According to this definition, Crustaceans may be distinguished from the Centipedes, Millipedes, Insects, etc., by the presence of two pairs instead of one pair of antennæ, and by possessing branchial and not tubular (tracheal) respiratory organs. The Arachnida may be separated from Crustaceans by having in front of the mouth only one pair of appendages, acting as jaws and not as antennæ, while respiration is effected by means of saccular or tubular ingrowths of the integument. Nor can there be any confusion between Crustaceans and the sea spiders, since the latter have no antennæ and all their appendages are placed behind the mouth, which is situated at the extremity of a tubular proboscis. But when we come to the Gigantostraca it is not so simple to point out the differential characteristics of the Crustaceans. It is true that the king crabs are easily distinguishable, and appear to be more nearly related to the Arachnida, yet the Trilobites, which seem to be ancestral forms of the king crabs, show marked affinities to the primitive Crustaceans.

In a few Crustaceans, especially those leading a terrestrial life, or inhabiting fresh water, the young is very similar to the adult, and gradually attains maturity without going through any marked change of form; but in the majority the young upon leaving the egg is unlike the parent, and only acquires its definite form after undergoing a series of molts. The earliest stage, which has been called the *Nauplius*, is a minute oval body, showing no trace of segmentation, and provided with a single median eye, and three pairs of swimming appendages, which become the two pairs of antennæ and the mandibles of the adult. This stage, however, is by no means of invariable occurrence, but is chiefly characteristic of the lowest members—the Entomostraca—and is rare in the higher Malacostraca. In some mem-

NAUPLIUS LARVA OF BARNACLE (much enlarged).

bers of the latter group, nevertheless, it does occur, as in one of the shrimps (*Penæus*). In this the Nauplius passes into a stage called the *Zoæa*, in which four pairs of appendages, representing the maxillæ and the two following pairs of limbs of the adult, have appeared, and the abdominal region has increased in length, although, like the greater part of the thorax, is still limbless. A pair of compound eyes is present on the sides of the head. After this so-called copepod stage, the large eyes become stalked, the abdomen continues to increase in length, and takes on the function of swimming, which was before performed by the antennæ, and the remainder of the thoracic and abdominal limbs appear. Since the thoracic limbs are provided with a distinct exopdite, as well as the principal branch or endopodite, as in the cleft-footed shrimps (Schizopoda), this larva is known as the schizopod stage. Lastly, the median eye and the exopodites of the motor-thoracic limbs disappear, and the adult form of the *Penæus* is attained. It is, however, exceptional among the higher forms for the young to be set free in the Nauplius stage. The young of the lobster, for instance, hatches in the schizopod condition; while that of the common crab appears in the Zoæa form, although characterized by the presence of a long dorsal spine, and a sharp beak on the carapace. Moreover, the two pairs of antennæ, the mandibles, and maxillæ, are of small size, while the following two pairs of limbs are relatively large, and forked. By means of these the minute transparent creature swims, and after undergoing several molts passes into a stage termed the *Megalopa*, which is much like the adult, but has enormously large eyes, and swims by flapping its long jointed abdomen like a shrimp.

ZOÆA STAGE OF CRAB.
(Enlarged.)

The Typical Crustaceans — Subclass **Malacostraca**

Much difference of opinion still obtains as regards the classification of Crustaceans, which are here divided into two main subclasses. In the present group, comprising the largest and most familiar forms, the number of segments in the

JAWS OF CRAWFISH.
a. Mandible; *b*, *c*. Maxillæ; *d*, *e*, *f*, 1st, 2nd, and 3rd Maxillipedes.

body is very generally nineteen (but never more), and each has a pair of appendages. The first five segments compose the head, which, except in some blind species, bears a pair of compound eyes, two pairs of antennæ, and three pairs of jaws, namely, a pair of mandibles in front, and two pairs of maxillæ behind. The eight segments behind the head, which constitute the thorax, may be united with the head, as in crabs, when the whole region is termed the *cephalothorax*, and the

shield that covers it the *carapace*. Sometimes too, as in the crawfish, the anterior three pairs of thoracic appendages are transformed into jaws, and on this account are called the *maxillipedes* or foot jaws; and in such cases only the remaining five pairs, called the trunk limbs, are large, and useful for locomotion or seizing prey. In less highly organized forms, all the maxillipedes may be free and foot-like, as in the mantis shrimps, or only the anterior pair, as in sand hoppers, may act as jaws. The remaining six segments, forming the abdomen, are usually provided with six pairs of small two-branched limbs, and to the last of these segments there is articulated a single plate or telson, while the limbs or uropods, are generally of large size, and form with the telson the tail fin.

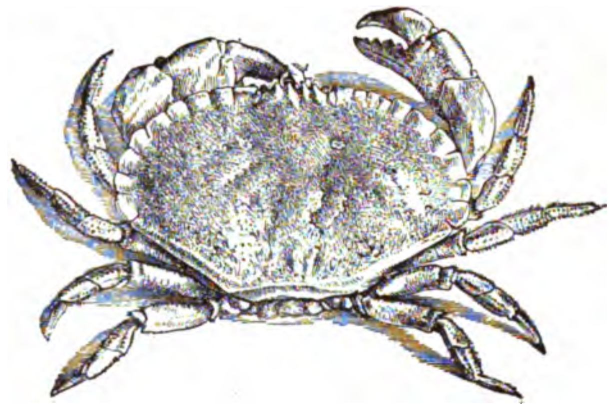
The Malacostraca are divisible into two series, the Podophthalmata, containing those in which the eyes are perched on movable stalks, and the Edriophthalmata containing those in which they are sessile, or if raised upon stalks not movable. The former are further distinguished by having the fore part of the body generally covered by a carapace; in the latter some of the thoracic segments are movable and there is generally no carapace.

Decapods The first order (Decapoda) of the stalk-eyed series is characterized by having the posterior five pairs of thoracic limbs strongly developed, and forming either walking or swimming legs, or prehensile pincers. The three pairs of maxillipedes are generally transformed into jaws; but in some of the lowest forms, as shrimps, the third or last pair are long and limb-like, so that in reality there are six pairs of large thoracic limbs. The gills, which are attached to the sides of the cephalothorax and to the basal segments of its limbs, are concealed in a gill chamber, formed by the lateral portions of the carapace. Each gill may be compared to a plume consisting of a central stem, to which is attached a number of delicate processes in the form of flattened plates or of filaments. The front aperture of the gill chamber is closed by a movable plate called the *scaphognathite*, and attached to the second maxilla. During life this plate is in constant motion, bailing out the impure water through the anterior opening, and thus compelling a flow of fresh fluid into the chamber through the openings at the hinder end of the carapace above the bases of the limbs.

Short-tailed Group — Suborder **Brachyura**

Decapods are divisible into two suborders, the Brachyura, or short-tailed, and Macrura, or long-tailed group. The first-named suborder contains those members of the order which may be called crabs. Here the abdomen, or so-called tail, is small, and shorter than the cephalothorax, against the lower surface of which it is usually tucked away. In the males it is generally narrow, and bears only one or two pairs of appendages, but in the female it is broader and is furnished with four pairs of limbs. In neither sex is its last segment furnished with a pair of uropods forming the tail fin. The lower surface of the cephalothorax is generally broad and triangular, and the third pair of maxillipedes are short and flattened, and form, when in contact, a plate completely covering the rest of the mouth organs. The group is divisible into five tribes, the first of these being the Cyclometopa, or those

with rounded foreheads. It includes most of the commoner species, such as the edible crab (*Cancer pagurus*), and shore crab (*Carcinus mænas*). The former belongs to the family *Cancridæ*, characterized by having the carapace much wider than long. As an article of food the male is more esteemed than the female, being larger and having larger claws. The two sexes, as in all crabs, may be distinguished by the size of the tails, this organ in the male being narrower, more pointed, and having fewer and smaller appendages than in the female. The family *Cancridæ* is represented in tropical seas by a large number of species and genera, some of which, such as *Actæa*, have the carapace covered with granules, and ornamented with a network of deep grooves.



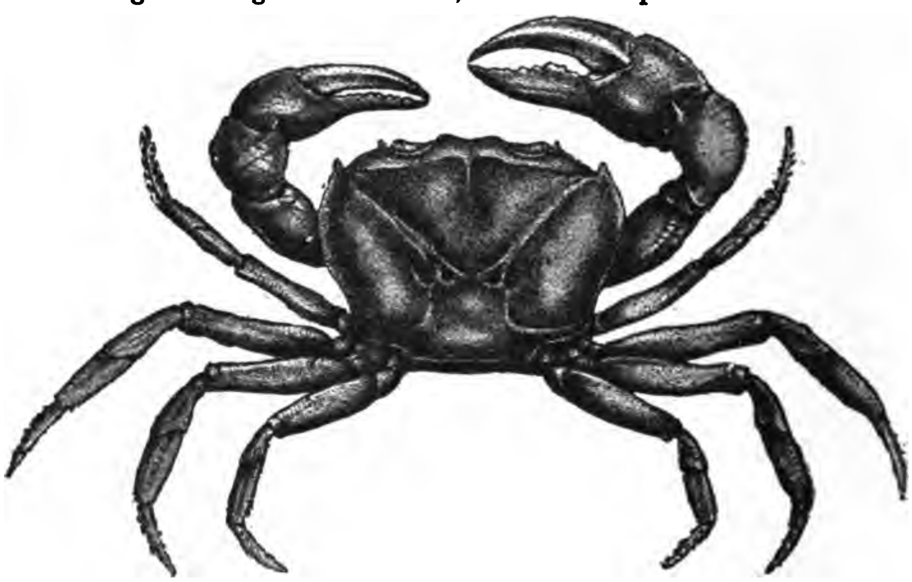
YOUNG EDIBLE CRAB.

The members of the family *Portunidæ* may be recognized by a modification of the last pair of legs. In the great majority of crabs these legs are like the rest, ending with a long, slender-pointed foot, which bears evidence to its being an organ for running, climbing, or crawling; but in the *Portunidæ* these legs are much flattened, the last segment in particular being dilated into an oval plate. The creatures are thus equipped with a pair of oars, by means of which they swim. Several species of the typical genus *Portunus* are found in British waters, and many of them are handsomely colored, although none are such expert swimmers as the tropical species, especially those inhabiting the gulf weed of the Atlantic. The peculiar motion of the oar-like feet has given rise to the name of fiddler crabs, so often applied to the group. The figured species (*Thalamita natator*) is a native of the tropical seas. The common British shore or green crab (*Carcinus mænas*), which is referred to this family, differs from the rest in having the legs of the last pair adapted for walking, being armed with a claw, and not

SWIMMING CRAB.
(Natural size.)

flattened into a paddle. Connecting the present with the following section, is the family *Thelphusidæ*, which contains a number of genera and species found in fresh-water streams, or on land, and sometimes ascending mountains, in temperate and tropical regions. One of the best-known species is the South European *Thelphusa fluviatilis*, which swarms on the muddy banks of the Lake of Albano, and is also abundant in the neighborhood of Rome, where it is captured for sale. Another well-known form is the Indian land crab (*T. indica*), to which the species here figured is nearly allied.

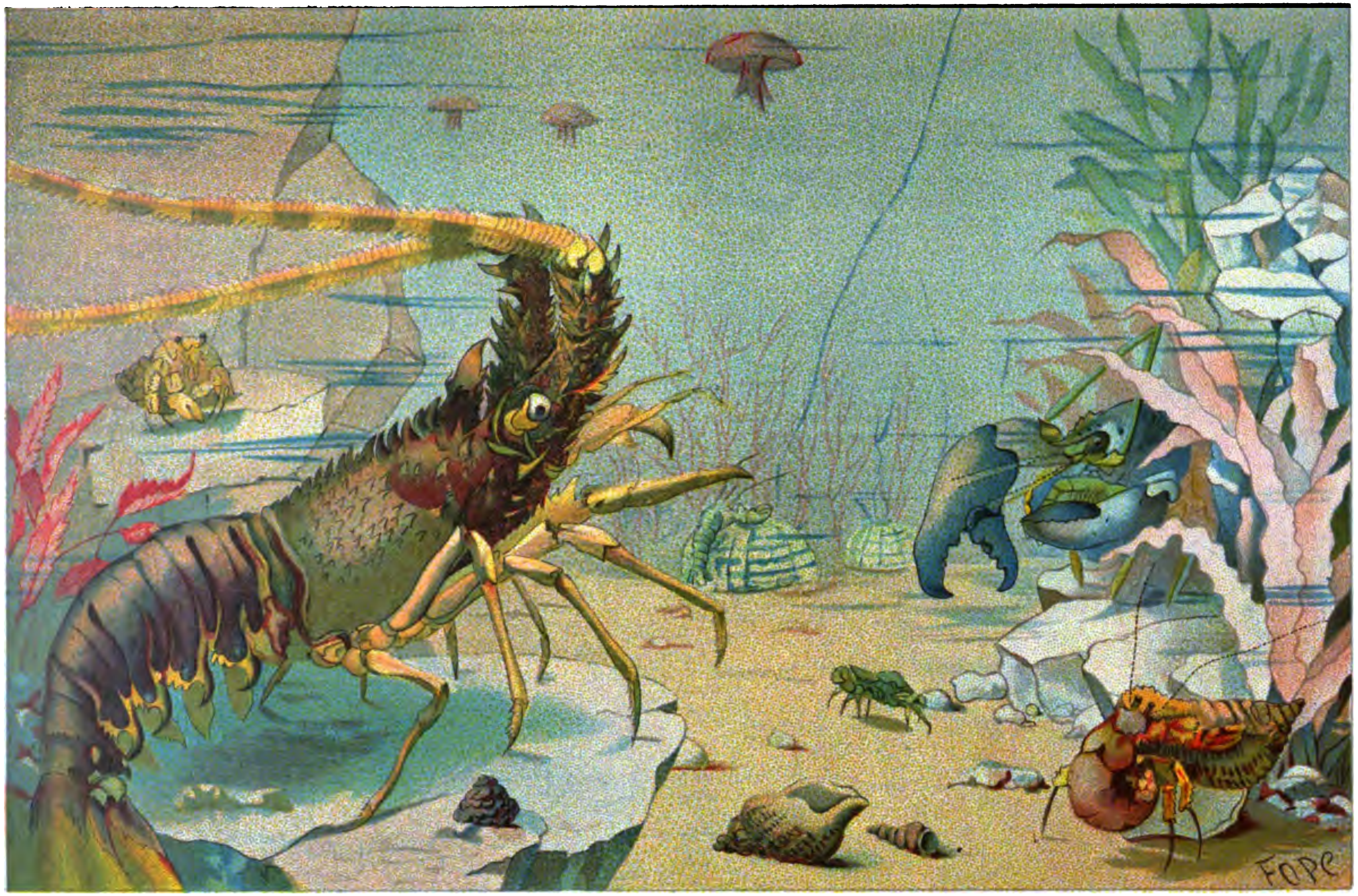
The second tribe (Catometopa) is characterized by the broad and squared frontal region of the carapace being bent downward. It is typically represented by the family *Gecarcinidæ*, including most of the true land crabs. A large number of these belong to the genus *Gecarcinus*, which has representatives in both the



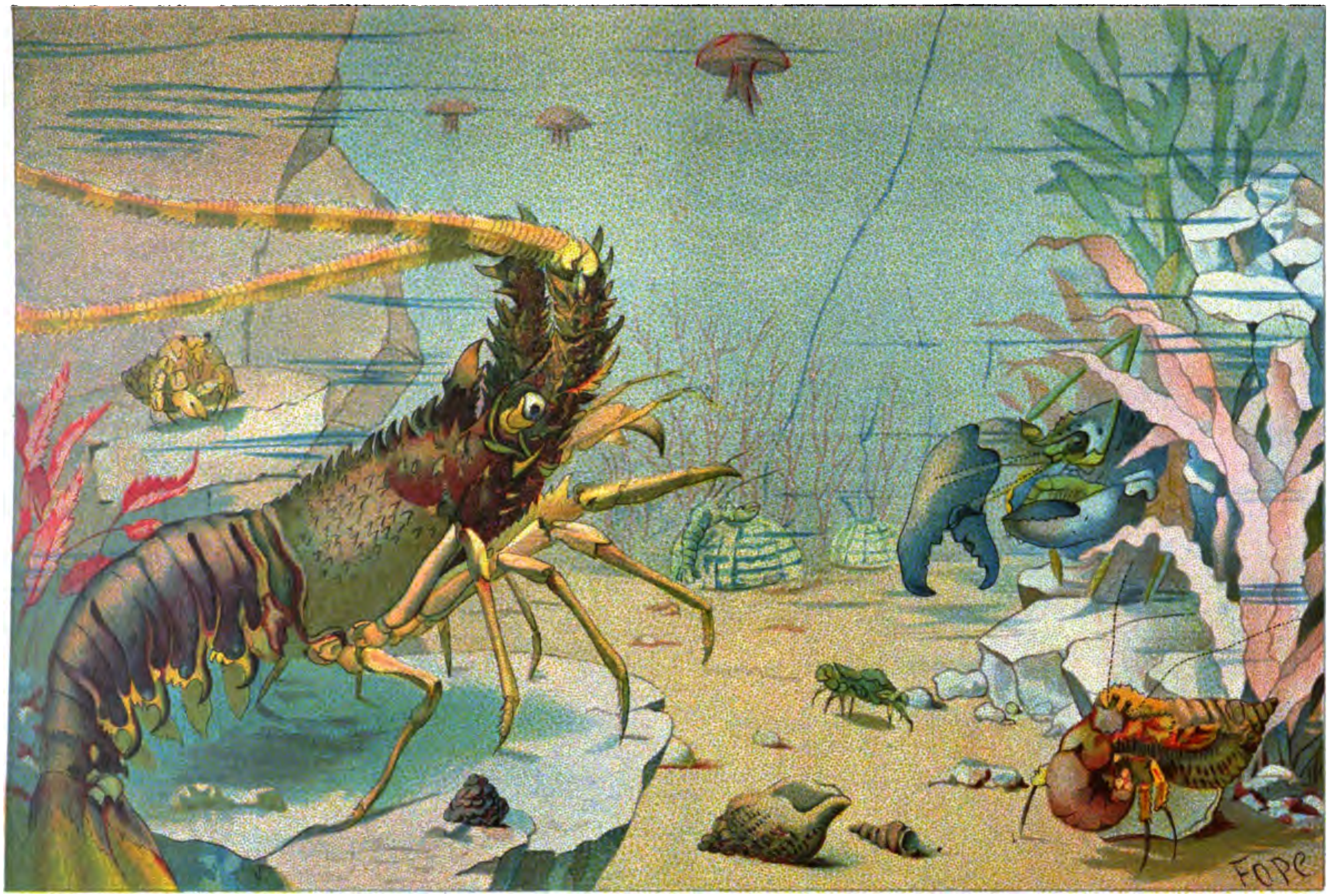
INDIAN LAND CRAB.
(Four-fifths natural size.)

Eastern and Western Hemispheres. Two inhabit the West Indian islands, and of one of these (*G. ruricola*) from Jamaica a full account has been given by Mr. Browne.

These crabs are generally found at a distance of from two to three miles from the sea, where they spend the day under stones, or in other sheltered situations. Pairing takes place in the spring; and shortly afterward the whole population makes a move for the sea, in which the females lay their eggs. When seized with this migratory instinct, nothing can turn them from their course. Issuing from hollow trees, from under rocks, and out of innumerable holes, they muster in a host so fast that they thickly cover an area more than a mile long, and upward of forty yards wide. The males lead the way, and the band proceeds in a straight line to its destination, climbing over everything that comes in its road, be it hedges, houses, churches, hills, or cliffs, and rather clamber up at the peril of their lives than make



CRUSTACEANS.



CRUSTACEANS.

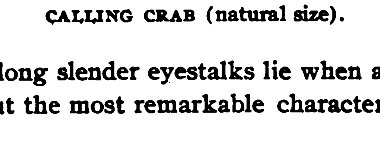
a circuit. Having reached the sea, the females lay their eggs, and the young hatch out as miniature copies of their parents. At the time of molting, which takes place late in the summer, the crabs retire to their burrows, close up the apertures, and remain there out of harm's way until the old shell is cast and the new integu-

SWIFT LAND CRAB.
(Natural size.)

ment hardened. It is while still in the soft state that these crabs, which are eaten by the natives, are considered most palatable.

The second family (*Ocypodidæ*) is typically represented by the swift land crabs (*Ocypoda*), which appear to be less strictly terrestrial than the last, although unable to endure a long sojourn in the sea. Indeed, from the adoption of a land life their breathing organs have become so modified that these crabs may be drowned by an immersion of twenty-four hours. They frequent sandy beaches, and when chased run with such speed, as to make their capture a matter of difficulty. They burrow deep perpendicular holes in the sand. In these they stay when the tide is up, but at low water they wander over the beach in search of food, which consists of sand hoppers or any offal cast up by the waves.

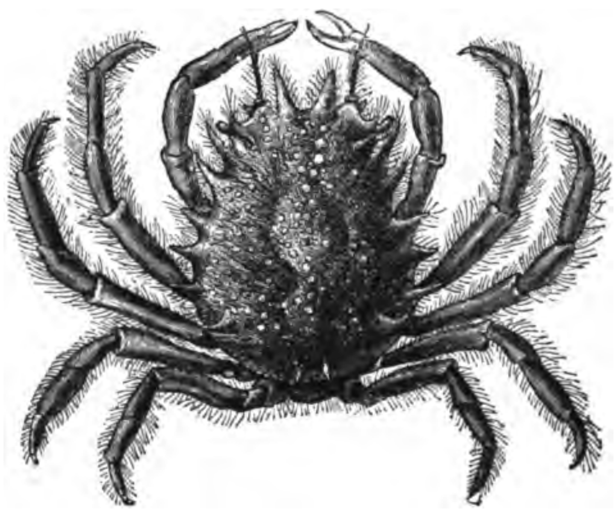
These crabs are gregarious, in the sense that numbers frequent the same spot. Each has a burrow to itself, and if one of them tries to enter by mistake the burrow of another, the rightful occupant makes a loud scraping noise to warn the intruder of its error; whereupon the latter retreats in search of its own abode. So strong is this instinct against trespassing, that a crab will always risk the chance of a fresh run for safety, rather than persevere in seeking concealment in the home of another.



CALLING CRAB (natural size).

Nearly allied to the foregoing are the calling crabs (*Gelasimus*), represented by a number of species from the warmer parts of the world. The carapace is broad and squared in front, and the long slender eyestalks lie when at rest along its front border, sunk in the orbits. But the most remarkable character-

istic is the enormous size of one of the pincers in the male; and it is from the habit of brandishing this claw, as if beckoning, that the name of calling crab is derived. So abundant are these crabs, that they may frequently be seen by the thousands either running over the sand or peering out of their holes. These holes, which are thickly scattered over wide areas, lead into burrows frequently a foot or more in depth. The crabs scrape up a heap of sand, and grasping the pellet with three of the legs of one side, carry it to some distance before letting it drop, then raising their eyes and peering round, dart back to the burrow, scrape together another heap, and persevere in the same manœuvere till the burrow is of the required depth. It was long supposed that the pincers of the male were used as weapons of attack and defense; but, in addition to its size, this limb is noticeable for its bright colors, and Mr. Alcock, who observed a number of males of an Indian species (*G. annulipes*)



THORNBACK CRAB.
(Two-thirds natural size.)

waving their large claws in the presence of a female, has suggested that their object in so doing is to make a display of their gaudy ornamentation and thus influence her choice of a mate.

The third family, *Grapsidæ*, contains species which for the most part are shallow-water forms. They are widely distributed, and attract the attention of travelers both on account of their bright colors and their extraordinary activity. Possessing long and powerful legs, tipped with sharp strong claws, they are able to dart among the rocks on the coast with amazing speed, while by means of their flattened carapace and limbs they can slip away into the narrowest clefts and chinks. Unlike the majority of the family, the little gulf weed crab (*Planes minutus*) occurs in temperate and tropical seas, among the floating weed, and it is said that Columbus adduced its presence as an argument in favor of the proximity of land when his sailors were on the verge of mutiny. The crabs of the family *Pinnotheridæ* have the carapace soft and membranous and the orbits and eyestalks are small. An in-

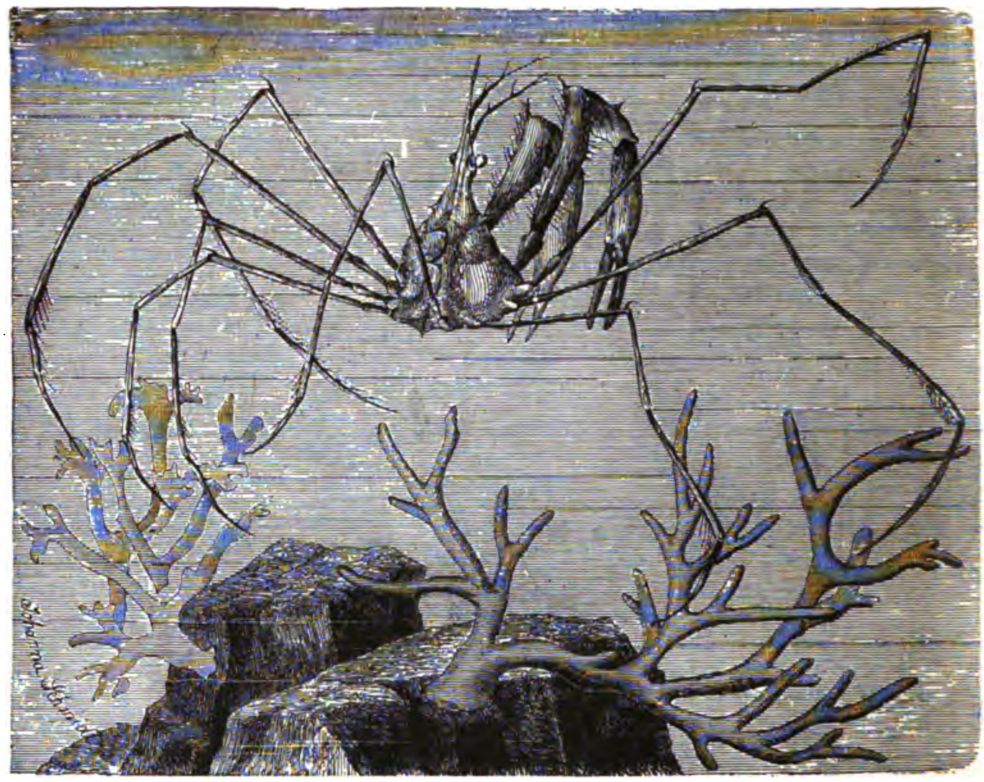
teresting fact connected with them is their habit of living in association with other animals; many species being found hiding between the shells of bivalve mollusks, and they have also been discovered lodged in the interior of sea cucumbers. Entering this strange retreat in the zoæa stage, they never quit it of their own choice.

In the next tribe, Oxyrhyncha, the carapace is generally narrowed in front and wide behind, and furnished between the eyes with a distinct beak, which is sometimes double and of great length. On its dorsal surface the carapace is usually roughened with spines or tubercles, and frequently furnished with hooked hairs. These crabs frequent deep water, and, at least, on the English coast, are regarded by fishermen as spiders. The characteristics of this group are shown in the figures of two British species, the thornback crab (*Maia squinado*) and the long-beaked spider crab (*Macropodia longirostris*). Also belonging to this tribe is *Macrochira kæmpferi*, which is not only the largest crab, but the largest crustacean known. It inhabits the seas of Japan, and is said to be able to span eleven feet with its outstretched pincers.

A peculiarity of many of this group is their extreme untidiness, owing to the quantities of seaweeds, zoophytes, and other marine objects affixed to the carapace and limbs; and it has been ascertained that the presence of these extraneous bodies is not the result of chance, but that they are placed there, presumably for the purpose of concealment, by the crabs themselves. This feat they are enabled to perform owing to the flexibility of their pincers, and to the hooked hairs and spines with which the carapace is studded. Some examples of *Hyas*, deprived of their covering of foreign bodies, were placed under observation in an aquarium of which the bottom was covered with a layer of sponge. Contrary to their habitual sluggishness of manner, the crabs appeared much perturbed, running first to one side then to the other in the aquarium. Soon, however, by means of their pincers they tore off small fragments of the sponges, and, after first putting them to their mouths, placed them finally upon the dorsal surface of the carapace or limbs, sticking them there with a rubbing movement. Sometimes after several vain efforts the crab brought the fragment afresh to its maxillipedes and then repeated its efforts to make it adhere. The animal persevered in these manœuvres until the piece of sponge remained fixed in the spot where it wished to place it. By continuing to act in this fashion the crab succeeded in completely changing its appearance, and in rendering itself indistinguishable among the objects that surrounded it. The crab proceeded in exactly the same fashion when the bottom of the aquarium was strewn with seaweeds or any kind of zoophytes. Moreover, it was observed that some specimens, clothed with seaweed, which were left in an aquarium of which the bottom was covered with sponges did not hesitate to take off their old clothing and put on a new one of sponges.

The present tribe also contains the family *Parthenopidæ*, the species of which, although not armed with spines and hooked hairs for holding foreign objects, are yet protected in the midst of their surroundings, by having the carapace covered with pits and variously shaped depressions, giving it a roughened corroded appearance, and consequently imparting a resemblance to pieces of rock or fragments of dead coral.

The sharp-nosed crabs, forming the tribe Oxystomata, are so called because the carapace is produced in front into a short beak-like prominence, while the external maxillipedes which cover the mouth are narrowed and pointed at the apex. The



LONG-BEAKED SPIDER CRAB.
(Natural size.)

families belonging to this group present great diversity of structure and habits, the *Matutidæ* being active swimmers and resembling the *Portunidæ* in having their posterior legs transformed into flattened paddles, while the *Calappidæ*, which live a sluggish life on the floor of the sea, have the sides of the carapace produced into shelf-like plates covering the legs, and the upper edges of the pincers supplied with large crests. The latter shut in the cephalothorax in front, so that when at rest the whole animal is inclosed in a casing of shell, and resembles a smooth pebble on the sea bottom. Some of the species of the family *Leucosiidæ* are remarkable for the porcelain-like appearance and texture of the carapace, while in others, as in *Ebalia*, this plate is granular and corroded. Three or four

DROMIA CRAB.
(Natural size.)

species of the latter genus occur in British waters, but the majority of the Oxystomata are inhabitants of the Tropics. In the genus *Dorippe*, belonging to the family *Dorippidæ*, the last two pairs of legs are short and raised on the upper surface of the body behind the carapace. In this position and structure they are adapted for carrying foreign bodies to serve as a protection.

The aberrant forms constituting the tribe Anomala differ from the other members of the suborder in having sometimes as many as fourteen pairs of gills, and also in that the apertures of the oviducts are situated upon the basis of the third pair of legs and not upon the breast plate of the cephalothorax. Moreover, as in the *Dorippidæ* of the preceding tribe, the last or last two pairs of legs are shorter than the rest, and dorsally placed, as shown in the illustration of the common *Dromia vulgaris*. The crab uses these limbs to hold foreign bodies like sponges and shells beneath which it thus lies concealed.

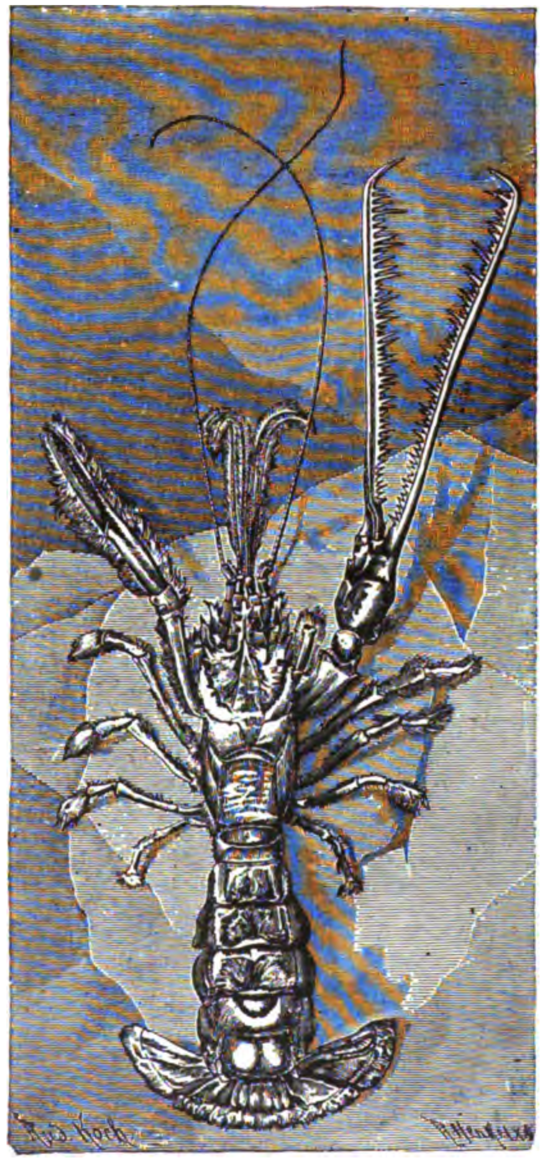
LONG-TAILED GROUP — SUBORDER **Macrura**

This suborder, comprising the lobsters, hermit crabs, prawns, and shrimps, is distinguished by having the abdomen or tail usually of large size, and constituting a powerful flapper for swimming, in which function it is assisted by the enlargement of the appendages of its last segment to form with the telson a powerful tail fin. The external maxillipedes are slender and leg-like, and the antennæ usually longer than the body. The first tribe, Anomura, contains forms which typically have a symmetrical tail. With these were originally classified the anomalous crabs, and there is no doubt that some of the species bear a striking resemblance to the latter. This is shown in the illustration of the broad-clawed porcelain crab (*Porcellana platycheles*), which frequents rocks and seaweed at low water. It may be distinguished from the true crabs by its long antennæ, the presence of a tail fin, and the slender unflattened exteral maxillipedes. The most familiar members are the hermit crabs, which abound in all seas, and are represented by several British species. In the typical forms the integument of the abdomen is soft; and aware of its defenselessness, the hermit crab invariably thrusts itself for protection into some empty shell, which it subsequently never willingly quits, save for the purpose of changing its abode for a larger one, when compelled by the exigencies of growth. It is not an uncommon thing to find shells containing a hermit crab surmounted by a large anemone. The advantage to the crab of this association is considerable, for anemones are so distasteful that no fish will bite at them twice, and consequently a fish that would, under ordinary circumstances, greedily swallow a hermit crab, shell and all, will not so much as sniff at it if protected by an anemone. One of the commonest deep-water British hermit crabs, *Eupagurus prideauxi*, is invariably found associated with an anemone, but the latter adheres to the lower surface of the shell in such a

BROAD-CLAWED PORCELAIN CRAB (natural size).

(3230) HERMIT CRABS.

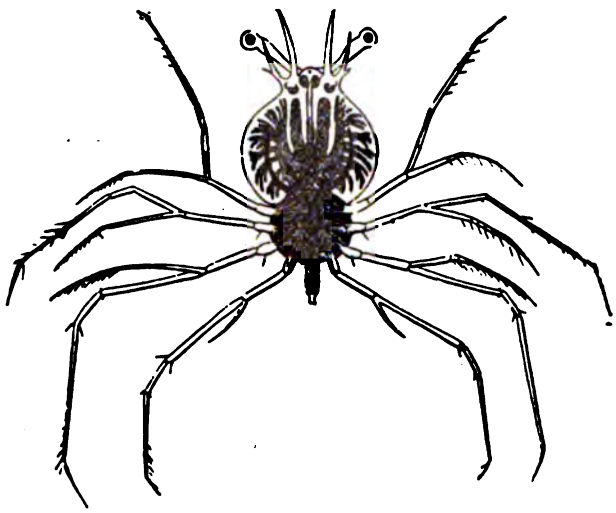
manner that its mouth and tentacles are situated immediately below the fore part of the crab's body. It is thus able to share in the meals that the crab procures for itself, and the companionship is consequently mutually beneficial to the two. An advantage conferred upon the crab by the presence of the anemone results from the fact that the latter gradually absorbs the shell in which the former is lodged, so that there is no occasion for it to change its abode with growth, the soft tissues of the polyp offering no resistance to the crab's increase in size. Certain hermit crabs have forsaken the sea as a permanent abode, and spend the greater part of their lives on land. For instance, the genus *Cenobita*, which occurs both in the West Indies and India, may be met with in forests far from the coast. The best known of these terrestrial forms is the great cocoanut crab (*Birgus latro*), found in the islands of the Indo-Pacific seas, and remarkable not only for its great size and habits, but also for having the abdomen symmetrical and covered above with a series of horny plates. These animals inhabit deep burrows, which they hollow out beneath the roots of trees, and carpet with fibres stripped from cocoanuts. Periodically, however, they are compelled to visit the sea to moisten their gills; and here they lay their eggs, the young being hatched and living for some time on the coast. They live principally upon cocoanuts, which fall from the palms, but they do not climb the trees after the fruit. To get at the contents of the nut, the crab first tears away the fibre overlying the three "eyes," and then hammers away with its claws at the latter until a hole is made, when it extracts the kernel by means of its smaller pincers. Some observers state that after drilling through the perforated eye, the crab grasps the nut in its claws and breaks it against a stone.



ONE-CLAWED LOBSTER, *Thaumastocheles zeleuca*.
(Natural size.)

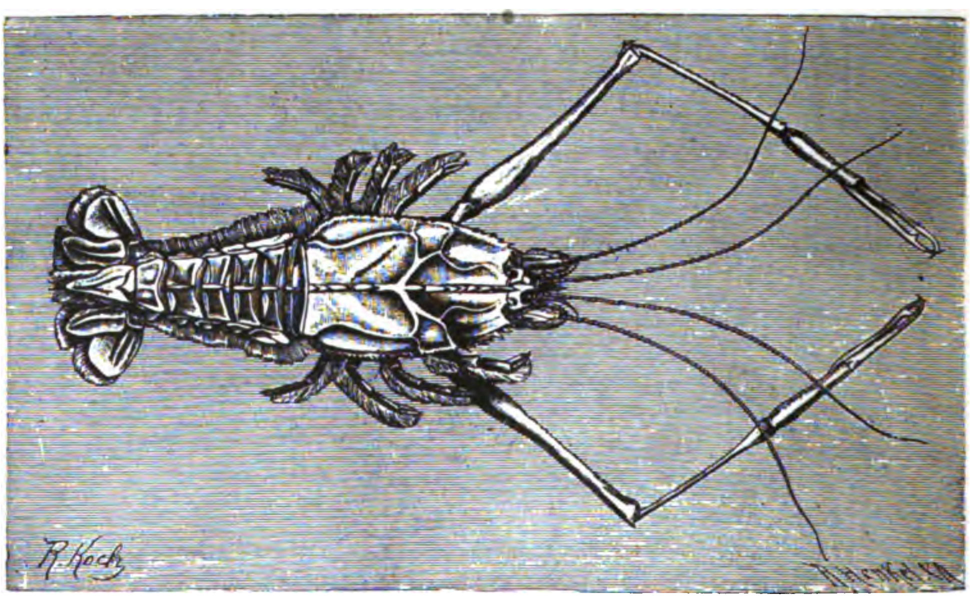
In the next tribe, or Thalassinidea, the carapace is much com-

pressed and has a small rostrum, but the abdomen is well developed and often wider in the middle than in front. As in the short-tailed group, the fourth pair of thoracic limbs are enlarged and generally completely chelate, while the four succeeding pairs, of which the last is smaller than the rest, usually terminate in simple claws. All the members of this group are exclusively marine, living at the bottom of the sea buried a foot or more in the mud. The figure on p. 3231 represents a species (*Thaumastocheles zeleuca*) obtained at a depth of four hundred fathoms in the West Indies. It is characterized by the extraordinary development of the pincers of the right claw, which are not only very long and slender but beset with spine-like teeth. The creature is totally blind, having lost both eyes and eyestalks.



LARVA OF CRAWFISH, THE SO-CALLED GLASS-CRAB.
(Natural size.)

In the tribe of the Scyllaridea none of the limbs of the thorax are truly chelate, and the antennæ are not furnished with an external scale-like basal piece. The best-known members of this group are the *Palinuridæ*, or rock lobsters, one member



SLENDER-CLAWED CRAWFISH, *Willemæsia leptodactyla*.
(Natural size.)

of which, the crawfish (*Palinurus vulgaris*), may be seen for sale in England. It is larger than the lobster, and has enormously long stout antennæ, and a spiny carapace but no claws. This species is figured on the left side of the colored plate. The second family, *Scyllaridæ*, contains a considerable number of genera (*Scyllarus*, *Ibacus*, etc.), mostly from tropical seas, remarkable for having the carapace broad and flattened, with the eyes inclosed in complete orbits on its upper surface, and the antennæ short and scale-like. In this tribe the larvæ are unlike those of crabs or lobsters. On account of their transparency and delicacy they are called

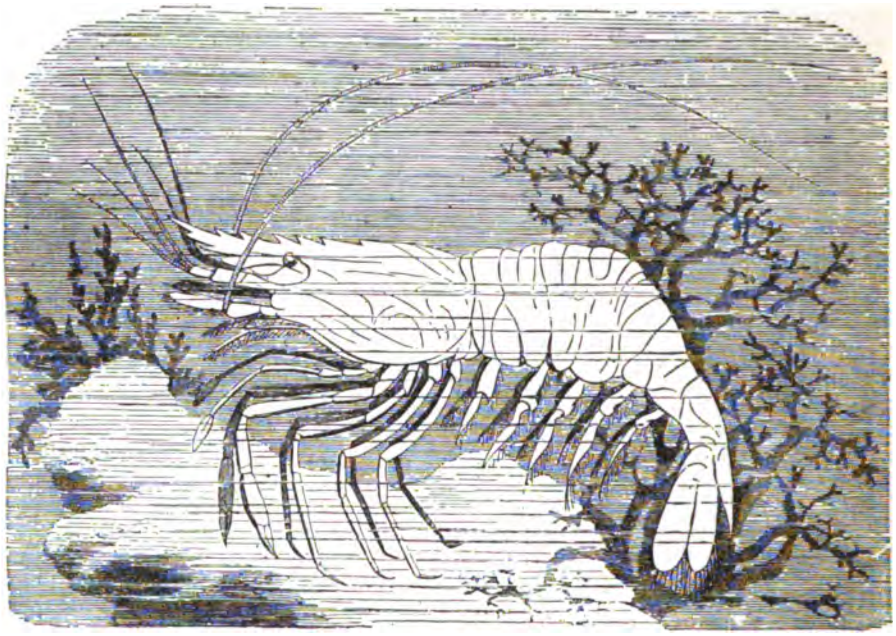
COMMON CRAWFISH.
(Slightly reduced.)

glass-crabs. The body is formed of three distinct parts, a large round-sided head, a smaller but also round-sided thorax, and a minute jointed abdomen which projects like a short tail from the hinder end of the thorax. The abdomen bears no limbs.

The lobsters and crawfish (Astacidea) have at least three pairs of the large thoracic limbs pincer-like, the first being much larger than the others. The antennæ are furnished with a distinct basal scale-like plate. The first family (*Eryontidæ*) contains several genera found in deep water in various parts of the world, the slender-clawed *Willemæsia leptodactyla* occurring in both the Pacific and Atlantic Oceans, at depths varying from thirteen hundred to over two thousand

fathoms. As in many deep-water species the eyestalks are rudimentary. The five posterior pairs of thoracic limbs are chelate in both sexes, and the first pair of antennæ have their inner branches long, while the carapace is flattish with a small rostrum.

The remaining three families, namely, the *Nephropsidæ*, or lobsters, the *Potamobiidæ*, and *Parastacidæ*, or true crawfish, are nearly allied. Among the former, the Norway lobster (*Nephrops*) is smaller than the common lobster, and has the pincers long, slender, and covered with scale-like tubercles. The common lobster (*Astacus gammarus*), from a commercial point of view, is one of the most important Crustaceans. The crawfish (*Potamobiidæ*), which live exclusively in fresh water, are very like small lobsters; the species known as *Potamobia fluviatilis*

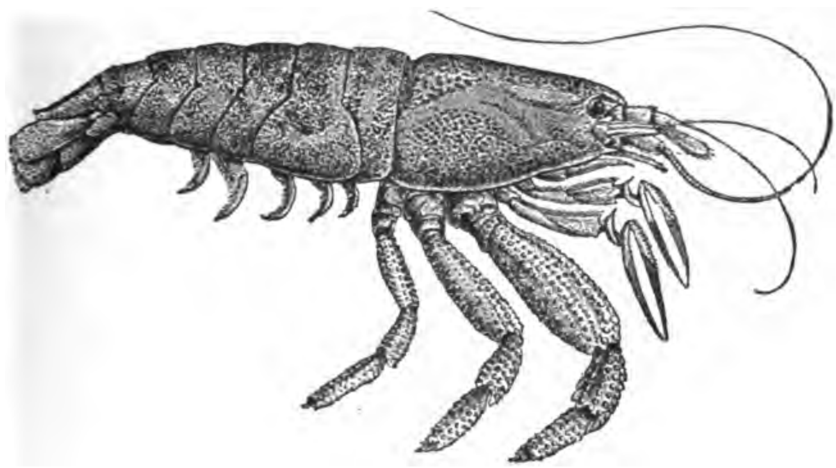


COMMON PRAWN.
(Natural size.)

being found in many streams in England. Throughout the day crawfish usually lurk under stones or the edge of banks, and creep out in the evening in search of food, which consists of worms, water insects, small frogs or fish, and plants and roots of many kinds. During the winter they seek the shelter of crevices or excavate deep burrows in the banks. In these they lie, with their antennæ stretched forward, and their claws ready to seize any passing object that may serve for prey. Pairing takes place in the autumn, and the female retires to her winter quarters to deposit her eggs, which vary in number from one to two hundred. After being laid, the eggs are attached to the abdominal limbs of the mother. During the winter they develop slowly and are not ready to hatch until late in the spring or the early summer. The young, which at first much resemble the parent and go through no metamorphosis, adhere tightly to heir mother's limbs, and do not

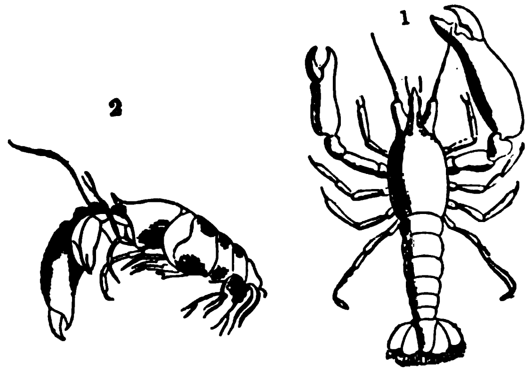
leave her until able to shift for themselves. Growth, however, although fast at first is a slow process, the crawfish not reaching maturity until about five years after birth. They probably live under favorable conditions for about fifteen or twenty years. Although not considered a delicacy in England, on the Continent and especially in France, they are much appreciated. It is said that in Paris alone from five to six million crawfish are consumed annually, and to meet the demand large numbers are imported from Germany and elsewhere, and artificial cultivation has been carried on with success. The crawfish belonging to this family are found in the Northern Hemisphere; but in the Southern Hemisphere several forms occur which are referred to another family, *Parastacidæ*, differing in the arrangement of the gills. Some of these forms are of large size, the Tasmanian *Astacopsis franklini* measuring a foot or more in length.

The next tribe, Caridea, embraces the shrimps and prawns, in which the last three pairs of thoracic limbs are never chelate, although the two pairs in front of



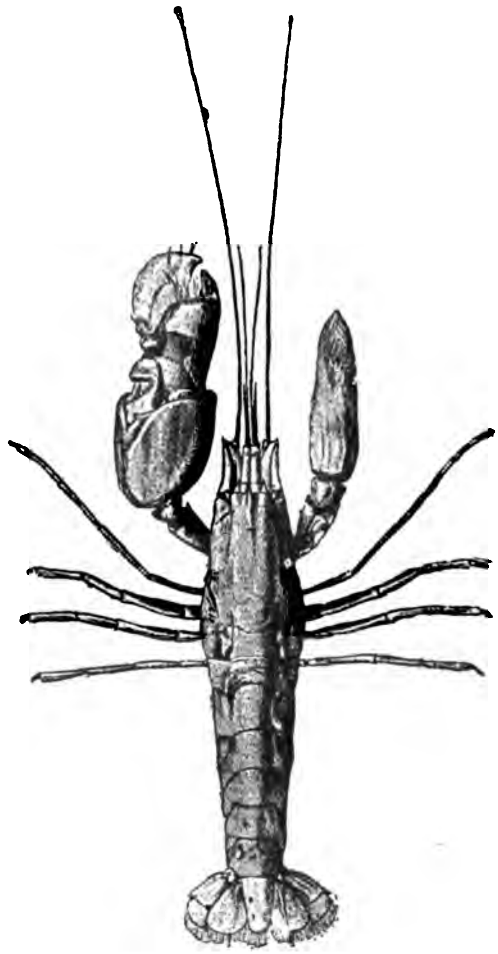
WEST-INDIAN PRAWN, *Atya*.
(Natural size.)

them are frequently so. The tribe is divided into three sections. The first of these, or Crangoninea, contains the family *Crangonidæ* or shrimps, characterized by having the first pair of trunk limbs subchelate, that is, with the terminal segment capable of being folded back upon the penultimate. The common shrimp (*Crangon vulgaris*) occurs in shallow water on sandy coasts of temperate countries of the Northern Hemisphere. Its color is a speckled gray, corresponding closely with that of the sandy sea bottom upon which it lives, and in which it buries itself when threatened with danger. To escape the vigilance of fish, shrimps resolutely keep themselves hidden during the day, but come forth at night to hunt for food. The presence of this they perceive by means of scent, since a blind shrimp will find food as quickly as an uninjured one. A second British species is Allman's shrimp (*Crangon allmani*), abundant in deep water in the Irish Sea and on the west coast of Scotland. It may be at once distinguished by the presence of two fine keels on the upper side of the sixth segment of the abdomen. Both have a short



1. MUSSEL PRAWN (*Pontonia tyrrhena*); 2. SPONGE PRAWN (*Typton spongicola*).
(Natural size.)

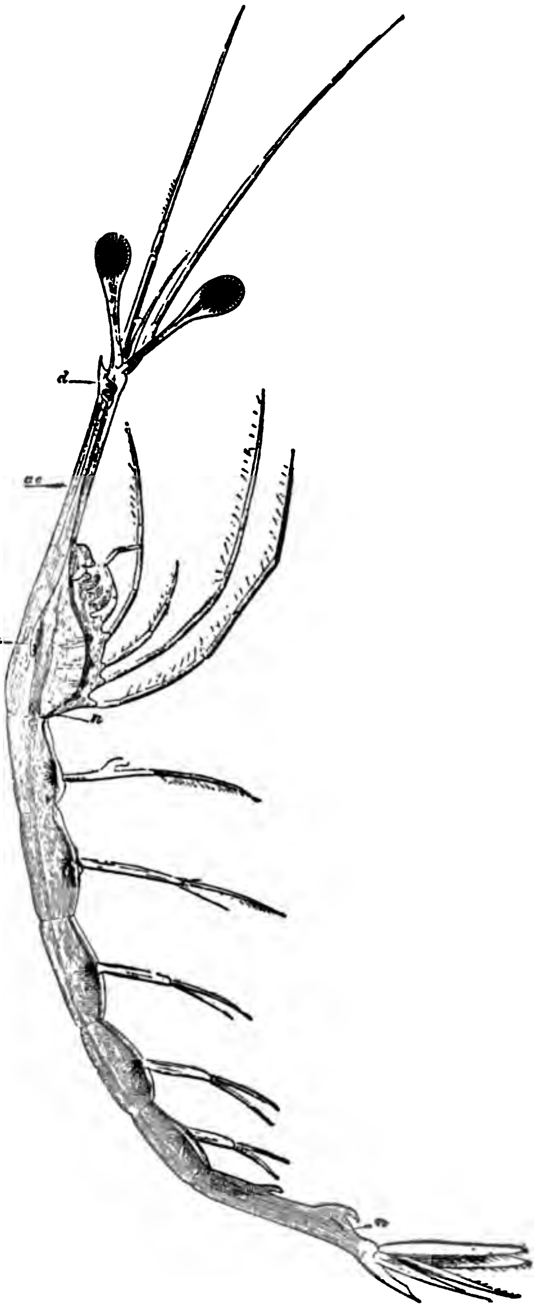
rostrum and no spines on the carapace; but some of the other members of the family have crests of spines on the carapace, and sometimes a largish rostrum as in the Arctic *Sclerocrangon boreas*. In *Rhynchocinetes typus* from the South Pacific, this rostrum is not only large but movably jointed to the carapace. The section Monocarpinea differs from the last in having the first and second trunk limbs completely chelate, and the second pair larger than the first. To this section belong a number of fresh and salt-water forms, and among them the *Palæmonidæ* or prawns. The general form of the body is shown in the figure of the common prawn (*Leander serratus*). In its native haunts the prawn is nearly invisible, being almost colorless, translucent, and marked merely with streaks of various tints. In the rivers of tropical countries occur prawns (*Palæmon*) rivaling lobsters in size, and remarkable for the length of their pincers, which may exceed that of the body. Among the largest are *P. jamaicensis* from the West Indies and Central America, and the Indian *P. lar*, so much esteemed when cooked as a curry. Also belonging to the same section is the family *Atyidæ*, containing a few genera such as *Atya* and *Caridina*, found in both Eastern and Western Hemispheres in fresh-water streams and lakes. In *Atya* the trunk limbs are curiously constructed, the first two pairs being short and subequal with the two fingers of the pincers tipped with a long tuft of hairs. The remaining three pairs, of which the first is much the stoutest, end in simple claws, and are studded with scale-like or spiny tubercles. It feeds on the organic matter contained in the mud which it gathers up in its nippers, com-



HOODED SHRIMP, *Alpheus*.
(Natural size.)

presses into pellets, and transfers to its mouth. The two small Crustaceans figured in the illustration belong to the family *Pontoniidæ*. Both are semiparasitic in habits, *Pontonia* living between the valves of mussel shells, and *Typton* being a lodger in sponges.

The Polycarpinea contains those species in which the wrist of the second pair of trunk legs is divided into several secondary segments. In other respects they are nearly allied to the last group. A common British representative is the red shrimp (*Pandalus montagui*), which gives its name to the family *Pandalidæ*, and is abundant upon many parts of the British coasts. This tribe is abundantly represented in tropical seas by the hooded shrimps (*Alpheidæ*), remarkable for the concealment of the eyes beneath the edge of the carapace, and for the enormous size, bright colors, and peculiar shape of the right or lèft pincers. With this instrument the hooded shrimps, which frequent holes and crevices in the coral reefs, are able to produce a clicking sound when angry or alarmed by the approach of danger. The last tribe of the suborder, known as Penæidea, appear similar to the Monocarpinea, but may be distinguished by the circumstance that the first three pairs of trunk limbs are chelate, so that only the posterior two terminate in simple claws. Some of the species of the genus *Penæus*, belonging to the family *Penæidæ*, attain a large size in tropical seas, and form an important article of commerce. Nearly allied is the little *Spongicola venusta*, which makes its home in glass sponges. In this neighborhood may be placed the anomalous family, *Sergestidæ*, in which the gills are impoverished or lost, while the first pair of trunk legs and sometimes the second are simple, the chelæ of the third are minute, and the fourth and fifth pairs are feeble, rudimentary, or absent. To



LONG-NECKED SHRIMP, *Leucifer*. (Much enlarged.)

this family belongs the genus *Leucfier*, remarkable for having the eyes and antennæ supported at the end of a long neck which extends in advance of the mouth. The gills are absent, respiration being effected by means of the general integument, which is so thin that the internal organs can be seen. In the figure the dark line (*n*) is the ventral nerve chord which throws out finer branches from ganglionic swellings in each of the segments; (*h*) is the heart, while immediately below the latter is the stomach, passing forward into the gullet and backward into the intestine.

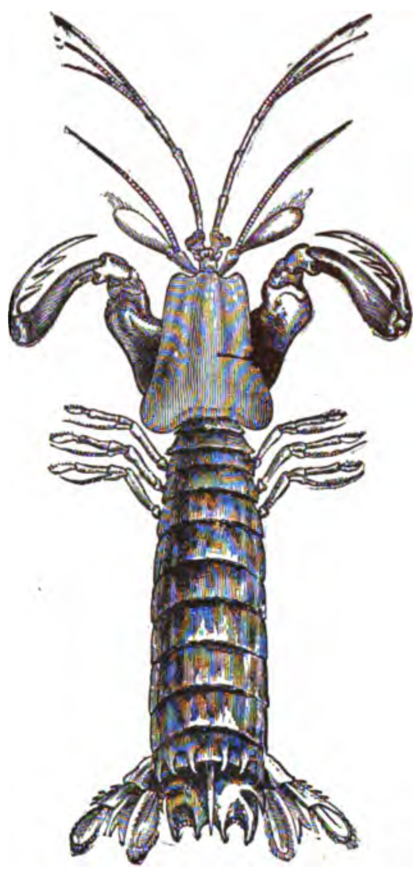
Cleft-footed Group — Order Schizopoda

This name is applied to a group nearly allied to the long-tailed Decapods; the chief difference between them being in the fact that in the present order the eight thoracic limbs are similar in structure, each being pediform and provided with a distinct exopodite on the second segment. The gills, which are attached either to the thoracic or abdominal appendages, generally project into the water, and are but rarely concealed in a chamber. The eggs are carried by the female beneath the trunk, and are frequently protected by the development of a pouch. The order contains several families embracing a large number of mostly marine forms, some of which occur at great depths. Of the British species, the finest is *Nyctiphanes norvegica*, which forms an important part of the food of herrings. It has luminous organs on the thorax and abdomen, and when swimming in a glass vessel, in a darkened room, appears like a flash of light. The young, as in all the members of the family *Euphausiidæ*, are hatched in the Nauplius stage. Most Schizopods are small, but species belonging to the genera *Lophogaster* and *Gnathophausia* measuring as much as six inches in length have been obtained. To the family *Mysidæ* belongs the genus *Mysis*, or opossum shrimps, among which is *M. veheta* from certain lakes in Northern Europe. Into these lakes the species is presumed to have entered while they were connected with the sea; a supposition borne out by the fact that it is nearly related to *M. oculata*, now living in the Arctic Ocean.

The Mantis Shrimps — Order Stomatopoda

The mantis shrimps (*Squillidæ*), which owe their name to the resemblance that their seizing limbs bear to those of the insect mantis, are abundant in tropical seas, where they sometimes reach a large size. Although bearing a general likeness to the long-tailed Decapods, they may be recognized by certain prominent characteristics. A glance at the illustration will show that the carapace is so short as to leave the hinder segments of the thorax uncovered, and, since the gills are attached to the abdominal limbs, it forms no branchial chamber. Only three pairs of limbs are modified into jaws, these being the mandibles and two pairs of maxillæ. The remaining eight pairs of thoracic limbs are foot-like, the large prehensorial pair corresponding to the second maxillipedes of a Decapod. Two kinds of mantis shrimp are occasionally met with in the English Channel, namely, *Squilla desmaresti* and *S. mantis*. The former is not uncommon along the shallower

parts of the shores of Jersey, but as it lives in deep burrows among the roots of sea grass, in a zone never uncovered by the tide, its appearance is infrequent. The allied North-American *Lysiosquilla excavatrix* is found in the sand below low-water mark, where it is protected from the full force of the ocean swell, and inhabits deep cylindrical burrows which are nearly vertical and go down for several feet.



MANTIS SHRIMP (reduced).

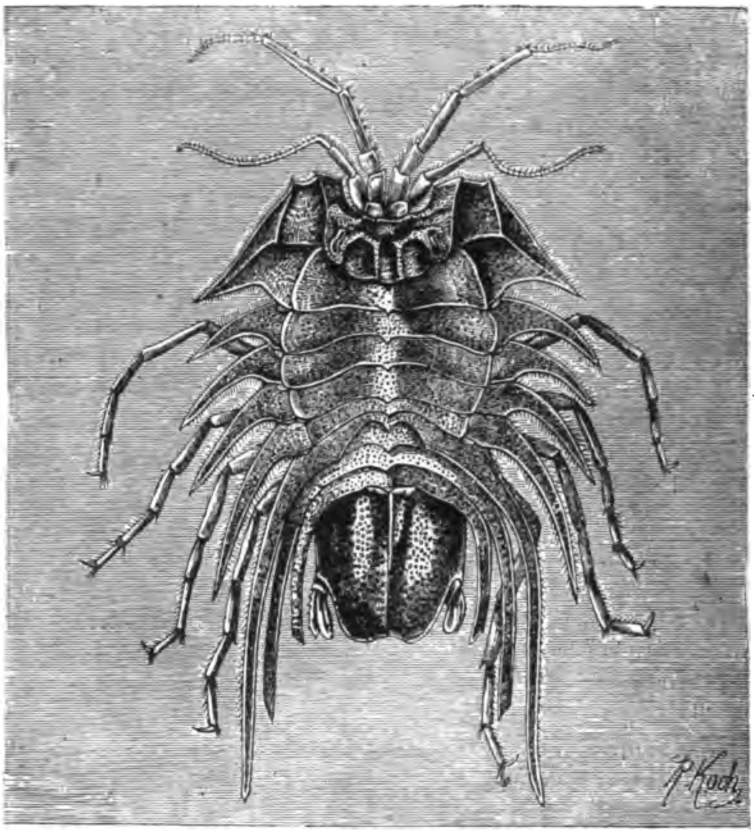
SESSILE-EYED SERIES — EDRIOPTHALMATA

We now come to the second great series of the Malacostraca, in which the compound eyes are generally sessile, and never mounted on movable stalks. As a rule, the last seven segments of the thorax are not covered by the carapace, and the last four are always free. The first order, Cumacea, is in many respects intermediate between the typical members of the last and present series, the thorax being larger and broader than the abdomen, while the carapace covers all but the last five segments. The front angles of the carapace are produced to meet in a kind of beak in front of the head, and the eyes are generally united in a single cluster of ocelli. None of the thoracic limbs are prehensile or chelate. The first five segments of the abdomen have no appendages in the female, although such limbs are present in the male. In the sixth segment appendages are present in both sexes, and form a fork-like termination to the body. Two of the best-known genera of the group are *Cuma* and *Diastylis*. The order, however, is relatively a small one, containing only a little over a hundred species. It has, nevertheless, a wide distribution, forms being met with in shallow and deep water in all seas, although the Arctic Ocean produces individuals of the largest size and in the greatest abundance.

Order ISOPODA

Unlike the last, this second order of the series exhibits great diversity of structure. As a rule, the posterior seven segments of the thorax are free, and at least the first three, and generally the first five segments of the abdomen are short and sometimes fused together, while the sixth is the largest, and bears the telson and a pair of appendages. The other abdominal appendages usually overlap, and are modified to act as gills. The seven thoracic limbs are generally large, and per-

form the function of walking or swimming organs, while the posterior five pairs at least have no exopodites. There are four pairs of jaws, namely, the mandibles, two pairs of maxillæ, and one pair of maxillipedes. Although there are many exceptions, it may be said that, as a rule, the body is broad, short, and flattened. Corresponding to the structural variations, the Isopods exhibit great diversity of habits and habitat. Most are marine, occurring in shallow waters or at great depths. Some live in fresh water, others on land, while others have taken to a parasitic life, and have thus to a great extent lost the characteristics of the order.



Serolis bromleyana.
(Natural size.)

Of the five tribes, the Valvifera have the posterior pair of abdominal appendages or uropods, transformed into valves or flaps, covering part of the lower surface, and constituting a chamber for the gills. The tribe contains two families, the *Arcturidæ* and *Idoteidæ*. The former are distinguished by their slender cylindrical shape, long lower antennæ, and the length of the fourth thoracic segment, which separates the posterior three pairs of thoracic legs from the anterior pairs by a wide space. The anterior thoracic feet are slender and hairy on the inner side, while the posterior feet are strong and prehensile, and enable the animal to fix itself to the branches of corallines. In the *Idoteidæ* the body is longish and narrow, the

thoracic segments being all of about the same size and shape, and their appendages short, stout, and used for walking. The anterior segments of the abdomen are short, and the posterior fused into a caudal shield. The species of the genus *Idotea* live in shallow water, and frequent places where there is an abundance of decomposing seaweed. They are essentially carnivorous, feeding on dead fish, worms, and mollusks.

Spoæroma (enlarged).

The tribe Flabellifera contains part of a marine species, in which the abdomen terminates in a tail fin, formed as in the macrurous decapods from the telson and the limbs of the last segment. There are too many families to mention, but some of the characteristic forms are shown in the illustration given. In the genus *Serolis*, which alone represents the family *Serolidæ*, the body is depressed and broad, the segments of the thorax being furnished with long pointed side plates, which impart to the animal a superficial resemblance to a trilobite. The legs and two pairs of antennæ are long. It is stated that the *Serolidæ* "live by preference on sandy ground, into which they burrow with their flat bodies up to the caudal plate. Their nourishment appears chiefly to consist of the organic materials distributed in the fine sand, diatomacea and organic detritus. Their locomotion is carried on less by swimming than by backward movements on the sandy ground, wherein the widely separated feet are used as a point of support." The species figured (*S. bromleyana*) is the largest, and has been taken at a depth of nineteen hundred and seventy-five fathoms. In the *Sphæromidæ* the convex body is capable of being rolled into a ball. Several species of *Sphæroma* occur on the coasts of Britain, and may be found, sometimes in numbers, sometimes isolated, beneath stones or among seaweed at low water. The next family (*Gnathiidæ*) contains the genus *Gnathia*, in which the males and females are so dissimilar that they were referred to two families. In the adult the male mandibles are powerful and prominent, and the head is large, squared, and at least as wide as the thorax. In the adult female, on the contrary, the head is small and triangular, without visible mandibles, and the thorax is much dilated. Many species are known from the European coasts, and one has been obtained at a depth of nine hundred fathoms. Belonging to this tribe, but representing a family by itself, is *Limnoria lignorum*, known to fishermen as the gribble, which is a persistent destroyer of submerged wood. The creatures are about one-sixth of an inch long, and of an ashy gray color; and the de-

MALE GNATHIA (enlarged).

FEMALE GNATHIA.
(Enlarged.)

struction they bring about is due to their habit of boring into timber below water-mark. They are vegetarians, and feed on the wood which they excavate. The members of the group known as fish lice are mostly of large size, the body being longish and oval, and the antennæ fixed on the front of the head, which bears in addition two large eyes. The anterior three pairs of thoracic limbs are stout and prehensile, terminating in strong curved claws, while the posterior four pairs are longer and thinner, and adapted for crawling. By means of their powerful fore-feet the *Cymothoidæ* attach themselves to both marine and fresh-water fish, and have a liking for the inside of the mouth of their hosts.

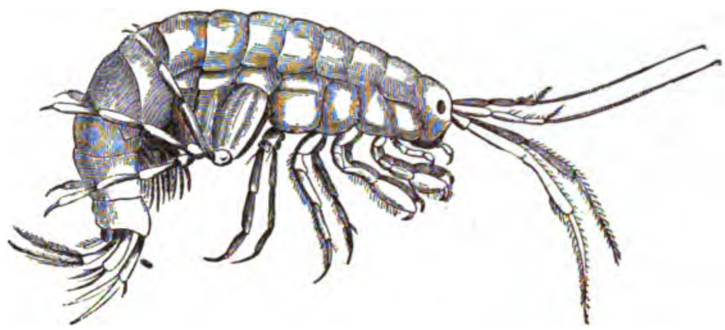
Another tribe is the Epicaridea, the members of which live parasitically upon other crustaceans. The form of the body in the female is, as a rule, distorted and unsymmetrical; but the smaller males are symmetrical, and are usually found adhering to the females. No group of Crustaceans seems exempt from the attacks of these parasites, but it is said that each species has its peculiar kind.

The best-known example of the tribe Asellota is *Asellus aquaticus*, distributed in fresh-water ponds and ditches almost all over Europe. The creature is of a grayish color, mottled with paler markings; and the male, which is longer than the female, measures about half an inch long. The body is long, narrow in front, with a small head, and the antennæ of the second pair are about as long as the body and head taken together. The seven segments of the thorax are free and of large size, but those of the abdomen have coalesced into a plate, from the end of which the long slender forked uropods project. The seven thoracic limbs are long, slender, and increase in length from the first to the seventh.

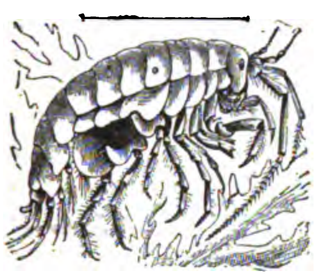
The tribe Oniscoidea contains the wood lice, in which the abdominal appendages are modified for breathing air. Like all crustaceans that have adopted a terrestrial life, they seem able to live only in air saturated with moisture. The body is usually broadly oval, convex above, and flat or hollow beneath, widest in the middle, and gradually narrowing toward the head and tail. The head is small, but the thorax large and seven jointed, the abdomen being short. Representatives of this tribe are found in all quarters of the globe. A familiar British species is the sea slater (*Ligia oceanica*), a large species living among the stones and rocks upon the coast above high water. The creature is nocturnal, and unless disturbed is not often seen during the day, but issues from the cracks and clefts of rocks in numbers at night. More obtrusive are the common wood lice *Porcellio scaber* and *Oniscus asellus*,

COMMON AND PILL WOOD LICE.
(Natural size.)

the former distinguishable from the latter by its duller color and the granules upon its segment; *Oniscus* being smooth and more or less variegated. Both these are rather flat, and incapable of rolling up into a ball; but the pill wood louse (*Armadillidium vulgare*) has the dorsal surface more convex, and when handled rolls up into a ball. On account of their resemblance to pills, these creatures were used for various maladies. In addition to its rounder shape, the pill wood louse may be recognized by the fact that the appendages of the last abdominal segment (the uropods) do not project like a couple of small tails from the hinder end of the body. Members of this group, differing but little from the species described, are widely distributed in all temperate and tropical parts of the world.

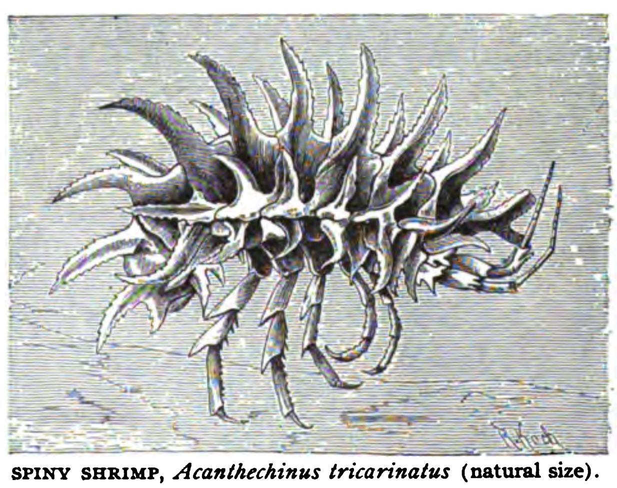


FRESH-WATER SHRIMP (enlarged).



SAND HOPPER (enlarged).

The tribe Phreatoicidea can only be briefly noticed. It contains the genus *Phreatoicus*, of which two species — both inhabiting fresh water — are known, one from New Zealand, and the other from Australia. The body is long and laterally compressed, the seven thoracic appendages are well developed, and the first is subchelate as in many Amphipoda, and the abdomen consists of six distinct segments, with the gills attached to its appendages. The last tribe, Chelifera, containing the genus *Tanais* and others, approaches the next order, and is distinguished by having the first pair of appendages following the jaws — that is the second maxillipedes — pincer-like. It further differs in that the abdominal limbs are used rather for swimming than for respiration; the breathing chamber is situated in the posterior portion of the thorax, and a constant circulation of water is kept up within by the movement of a process projecting backward from the maxillipedes.



SPINY SHRIMP, *Acanthechinus tricarinatus* (natural size).

Order AMPHIPODA

The Amphipods are allied to the Isopods, but the majority are recognizable by having the body narrow and flattened from side to side, instead of broad and flattened below. Moreover, the gills are attached to the thoracic feet, and the latter, instead of being broad, leaf-like, and overlapping, are foot-like, elongate, and used for leaping or swimming.

GIGANTIC ANDANIA, *Andania gigantea*. (Natural size.)

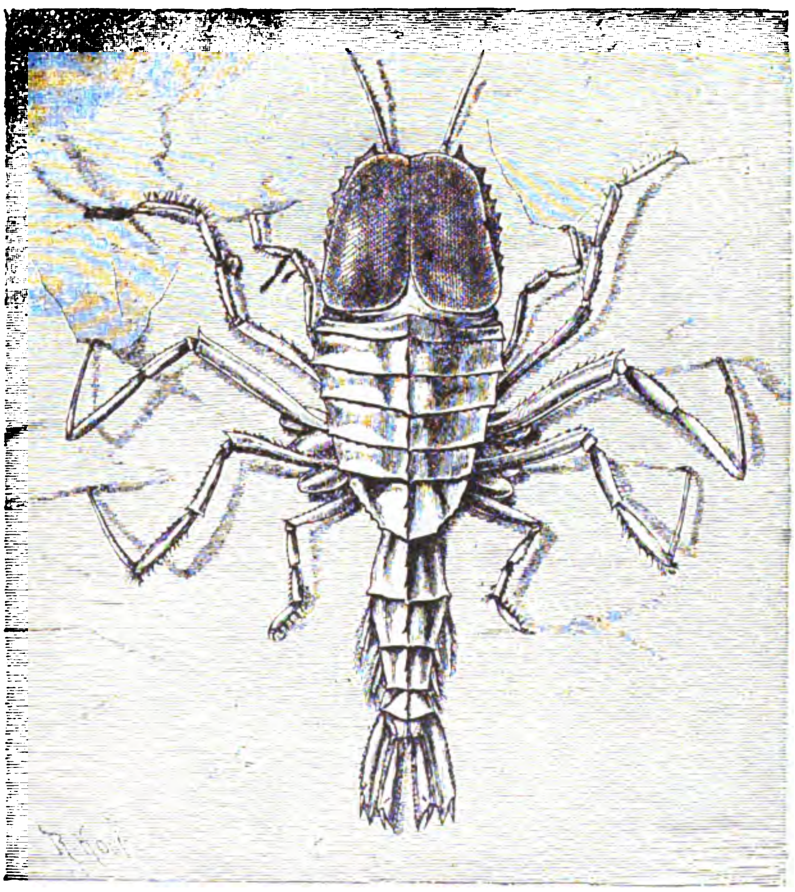
In the suborder Gammaridea the eyes are mostly of small size, and seldom prominent. The head does not coalesce with the first segment of the thorax, and the maxillipedes have a distinct palp; the abdomen being well developed, and bearing appendages. The form of the body is shown in the illustration of the fresh-water shrimp (*Gammarus pulex*), and the sand hopper (*Talitrus locusta*). The latter lives near the edge of the sea, beneath seaweed, or other substances, which prevent the evaporation of the moisture from the sand. Sand hoppers usually progress on land by leaps; and although some nearly allied forms are found far from the sea, the majority of the Gammaridea are marine, swimming by means of the constant play of their abdominal appendages, and, when thrown on the land, wriggling helplessly along on their sides. The fresh-water shrimp is common in the streams and ditches of Europe. During the cold months of the year they bury themselves in the mud, but emerge from their winter quarters on the first warm days of spring. Among deep-water forms, perhaps the most noteworthy are *Acanthechinus tricarinatus*, and *Andania gigantea*. The former has developed a spiny process at almost every possible point, each of the principal segments bearing three large and pointed spines, which have their edges armed like the blades of a saw. Very different is *Andania*, which is one of the largest of amphipods, reaching a length of two inches. Many members of the group construct tubular dwelling places, in which they take shelter, and lay their eggs. For instance, the British *Amphitha rubricata*, which is a brilliant crimson color, builds a nest of particles of seaweed

SKELETON SHRIMP. (Somewhat enlarged.)

cemented together with threads; while another species of the same genus (*A. littorina*) makes a tube by cementing together the edges of a leaf of growing weed, so as to make a tube open at both ends. Again, according to Bates, *Podoacerus capillatus* "builds its nest in a very bird-like manner in submarine forests; the nests consist chiefly of fine thread-like material, woven and interlaced, being established firmly in the branches of zoophytes; some small extraneous fragments are often bound with it, but these appear more the result of accident than intention. The form of the nest is somewhat oval, the entrance being invariably at the top. These nests are evidently used as places of refuge."

WHALE LOUSE, *Cyamus*.
(Natural size.)

In the tribe Caprellina the head has coalesced with the first segment of the thorax, and the abdomen is reduced in size, with most of its appendages wanting. The two principal families are the *Caprellidæ* or skeleton shrimps, and the *Cyamidæ* or whale lice. In the former the



TRANSPARENT OCEAN SHRIMP, *Cystosoma neptuni*.
(Reduced.)

thorax is cylindrical, and the abdomen, with its limbs, rudimentary. In the typical *Caprella* the third and fourth thoracic segments are without legs, but bear a pair of branchial vesicles; the appendages of the second pair are developed into claspers, and those of the last three pairs are of the ambulatory type. These shrimps seldom swim, but climb among the branches of seaweeds and zoophytes. When at rest, they grasp the stems of the weeds with their hind-limbs, and, holding the body in an erect position, wave their long antennæ in search of prey. In the whale lice, which live parasitically upon cetaceans, the short and conical head is united to the first segment of the thorax, which consists of six free, flattened segments. As in *Caprella*, the third and fourth segments of the body bear no limbs, but are furnished with a pair of gills, usually turned over the animal's back. In the female these segments carry beneath them plates, forming sacs, for the eggs. The second, fifth, sixth, and seventh segments are provided with short limbs, terminating in a sharp, pointed segment, which closes against the enlarged penultimate segment as the blade of a pocket-knife closes on its handle. By means of these chelate appendages the animals fasten themselves to the skin of cetaceans, thrusting their sharp claws into the epidermis, and adhering so firmly as to be able to withstand the dash of the waves.


PHRONIMA.
(Enlarged three times.)

The members of the tribe Hyperina differ from the last by the larger size of the head, the more prominent eyes, and the absence of a palp on the maxillipedes. To this tribe belongs the large *Cystosoma*, a pelagic animal, probably retiring during the day to a considerable depth, but occasionally coming to the surface. The animal is colorless and transparent, so that by transmitted light the internal organs can be seen. The head is large and inflated, with its upper surface occupied by two enormous eyes. The genus *Phronima* also contains species attaining a considerable size, examples of the European *P. sedentaria* exceeding an inch in length. As in *Cystosoma*, the second pair of antennæ are obsolete; the head is large, with the eyes placed upon its summit. There are seven pairs of large thoracic appendages, the third from the end forming a large and strong pincer.

The species are widely distributed, although most abundant in the Tropics. Like many pelagic animals, they are translucent, and mostly live in the mantle cavity of the ascidians *Pyrosoma* and *Doliolum*, where the eggs are laid, and the young hatched.

To a certain extent connecting the Malacostraca with the Entomostraca is a group of Crustaceans known as the Leptostraca, and containing the three recent genera *Nebalia*, *Nebaliopsis*, and *Paranebalia*, and a number of fossil forms. The affinities of the group seem to lie with the Phyllopods on the one hand, and the Schizopods on the other. The body is laterally compressed, and the whole of the cephalothorax and the first four segments of the abdomen enveloped in a carapace, which springs from the head, and is formed of two movable valves, closed by a muscle. Although the eight thoracic segments are overlapped by the carapace,

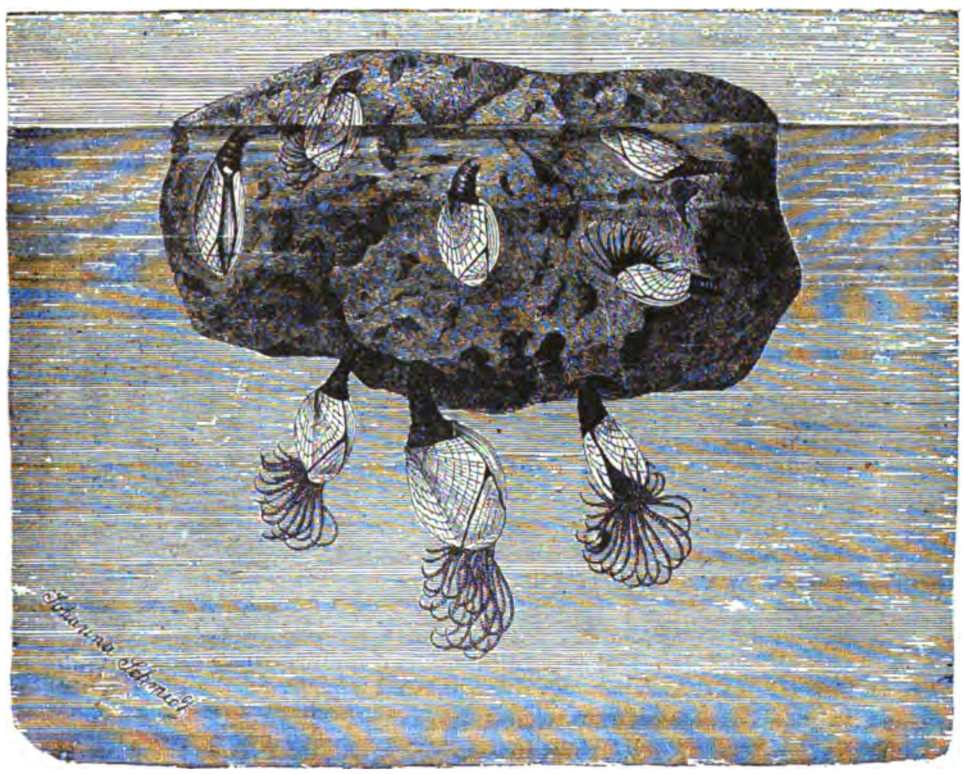
they are distinct and movable. The abdomen consists of eight movable segments, or two in excess of the normal number; but there are only nineteen pairs of appendages. The head bears a small, movable rostrum, and a pair of stalked eyes. The two pairs of antennæ are well developed, and there are three pairs of jaws. The appendages of the thorax are foliaceous. The members of this group are marine, and widely distributed, being found in cold and warm latitudes. The female carries the eggs attached to her thoracic feet.

SUBCLASS **Entomostraca**

The Crustaceans of this division are small, and vary much more than the Malacostraca, from which they differ in the following features: The number of body segments is not constant, but either greater or less than nineteen, and, as a rule, there are no appendages to the abdomen. In the majority of cases the young are hatched as a Nauplius.

THE BARNACLES — Order CIRRIPEDIA

The adult members of this group are so unlike typical Crustaceans that it can hardly be a reproach to the older naturalists that they failed to discover their affinity. Two well-known members of the order are the barnacles so frequently attached



BARNACLES ATTACHED TO PUMICE.

to the bottoms of ships or floating timber, and the acorn barnacles covering the rocks on the coast. The barnacle (*Lepas*) consists of a tough longer or shorter

STALKLESS BARNACLE.
(Natural size.)

stalk, one end of which adheres tightly by means of a cement to the timber or ship, while to the other is attached an oval compressed body incased in pieces of shell,

ACORN BARNACLE.
(Natural size.)

through two of the valves of which can be protruded six pairs of slender, bristly, two-branched, filamentous limbs. These limbs, being the appendages of the thorax, keep up a constant sweeping motion, whereby particles of food are washed into the mouth that lies below them. The abdomen is undeveloped; but the rest of the body is enveloped in a fold, or mantle, supporting the outer shelly skeleton. The jaws consist of two

PARASITIC CIRRIPEDE,
Sacculina.
(Natural size.)

pairs of maxillæ, and a pair of mandibles, and the lower part of the head is inferiorly continued into the stalk, which contains the gland secreting the cement. If a barnacle be carefully removed from its point of attachment, the remains of the first pair of antennæ may be observed on the adhesive surface. When first hatched, the young are in the Nauplius stage, being furnished with a median eye, and three pairs of appendages, of which the posterior two are branched. After swimming for a while by means of these appendages, the larva molts several times, and passes into a second stage, in which, with its two eyes and compressed carapace, it resembles a *Daphnia*. The rudiments of the six pairs of thoracic legs appear behind the mouth, and the first pair of swimming appendages, become antenniform, each being provided with a sucker. By means of these suckers the larva fixes itself to its permanent resting place, and, the cement gland pouring out its secretion, glues the crea-

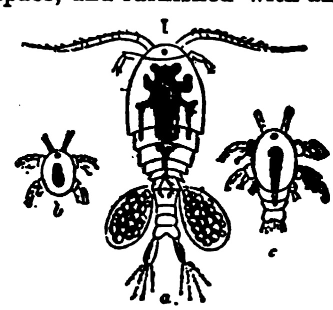
PARASITIC BARNACLES.
Upper Figure — *Peltogaster curvatus* (enlarged 1½ times); Lower Figure—*Nauplius* larva of *Parthenopea* (enlarged 200 times.)

ture firmly to its point of attachment. Hence it follows that the fixed end of the stalk is the front extremity of the body. In the allied stalkless barnacle (*Megalasma*) the shell is attached directly to the support. We are thus led on to the acorn barnacles (*Balanus*), in which the entire animal is inclosed in a shell formed originally of six pieces, which grow into a tube of variable length. Some of the latter group (*Balanidæ*), namely, the genus *Coronula* or coronet barnacles, attach themselves to the skin of whales. The burrowing barnacle (*Tubicinella*) has the same instinct. When adult it is long and cylindrical, consisting of a stout, stony rod, marked with a series of annular ridges. This is buried deeply in the skin of whales, sometimes penetrating as far as the blubber.

These Cirripedes are not true parasites, inasmuch as they do not extract nourishment from the animal to which they are attached; but many members of the group live exclusively upon other living beings, and nourish themselves at their expense. One form, for instance, *Proteolepas*, is in the adult condition a maggot-shaped, limbless, shell-less body, living within the mantle chamber of other members of the same order; while the root-headed Cirripedes (*Rhizocephala*) live parasitically upon the higher crustaceans. They are degenerate forms, possessing neither appendages nor segments, the body being a mere sac, devoid of alimentary canal, and absorbing nutriment by means of the root-like processes branching throughout the body of the host.

BIVALVED GROUP — Order OSTRACODA.

This order is a small assemblage characterized by the possession of a bivalved shell, formed from the right and left halves of the carapace, and furnished with an elastic hinge to separate the valves and a muscle to keep them shut. The shell incloses the body which is unsegmented, has a rudimentary abdomen, and bears seven pairs of appendages, namely, two pairs of antennæ, three pairs of jaws each belonging to the head, and two of limbs attached to the thorax. These limbs, however, are stout and narrow, and, as a rule, there are no special respiratory organs. Ostracods occur both in fresh water and the sea; the best-known forms being *Cypris* and *Cythere*. The former contains species found in ditches and ponds in England. When the waters in which they live dry up, the species of *Cypris* bury themselves in the mud until rain falls; the eggs, which are spherical, being attached to aquatic plants. The species of *Cythere* are mostly marine, haunting rocky pools on the coast and crawling among the seaweed. In *Cypridina*, on the contrary, which is also marine, the animals dart about with velocity; the females carrying their eggs between the valves of the shell attached to their feet.

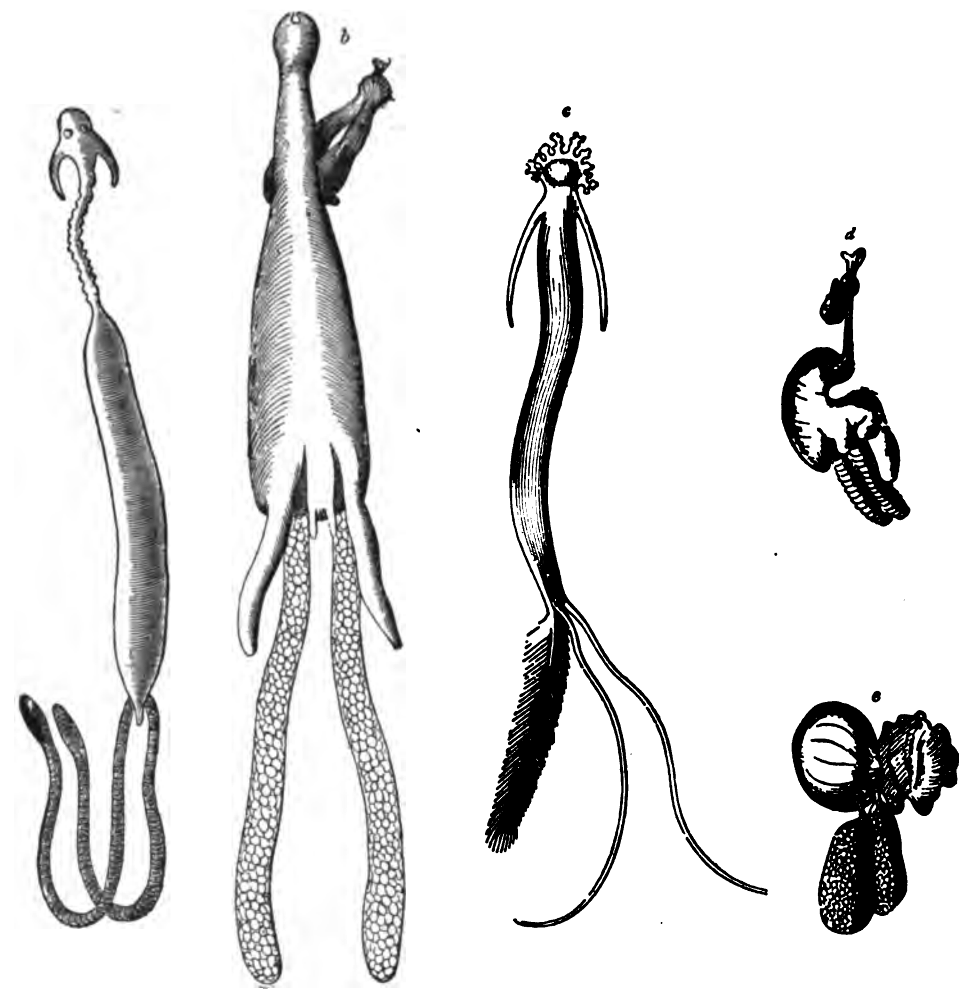


COPEPODS.

a. Female *Cyclops*, with egg sacs; *b*, *c*. *Nauplius* and later larva of same.

Oar-footed Group — Order Copepoda

In the free-living members of this group, the body is elongate and segmented; the thorax bears four or five two-branched swimming feet, and the abdomen is without appendages. A common fresh-water form is *Cyclops*, the structure of which serves as a type of that of the order. The body is broad in front and

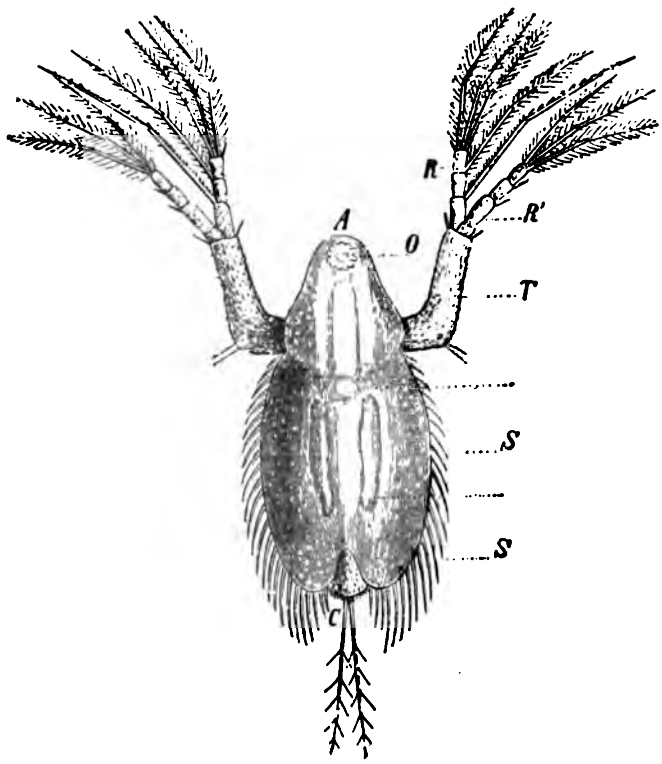


FISH LICE.

a. Lernæonema (enlarged 3 times); *b. Brachiella* (enlarged 9 times); *c. Pennella* (enlarged 5 times); *d. Hæmobaphes* (natural size); *e. Caligus* (enlarged 3 times).

tapering behind, being thus pear shaped in outline. The normal five pairs of head appendages are well developed, the first pair of antennæ being long and acting as oars. The dorsal elements of the head are fused to form a carapace, which bears a single eye in front and is behind united to the first thoracic segment, the remaining five of this region being free. The abdomen consists of four narrow cylindrical

limbless segments, but the last bears a pair of processes severally tipped with a tuft of four long bristles. The eggs are carried by the mother in a couple of oval sacs attached to the last segment of the thorax, and so prolific are these creatures, that a female, it has been calculated, will in a year produce over four thousand million young. The young when hatched is an oval *Nauplius* (*b*), which gradually acquires the characteristics of the adult. Closely resembling the preceding is the marine *Cetochilus*, which is devoured in large quantities by whalebone whales. These crustaceans are of a bright red color, and when seen in myriads give the sea the appearance of being stained with blood.



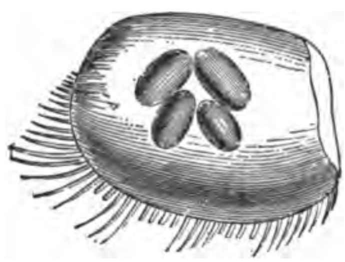
SPINY-TAILED WATER FLEA, *Acanthocercus*.
(Much enlarged.)

The Copepods hitherto noticed are spoken of as the Eucopepoda, but we now come to a number of genera which have taken to a parasitic life, these Epizoa or Parasitica, being strangely unlike the higher forms. As one of the least modified types, may be mentioned the carp louse (*Argulus*). Of the more degenerate types, the structure is exemplified in the cut on p. 3250. In these the body may be broad and flat, as *Caligus* (*e*), which is frequently found upon the codfish and the brill, or long and worm-like, as in *Lernæonema* and *Pennella* (*a* and *c*), the former being a common parasite on the herring and sprat, while in *Lernæa*, the gill sucker, to which *Hæmobaphes* (*d*) is allied, the body is swollen and twisted in the form of the letter S. The two long processes represented in the figures projecting

from the posterior end of the body are the egg sacs. The appendages of the head and thorax are more or less reduced, being either absent or converted into adhesive hoops or suckers.

Order CLADOCERA

The members of this order take their names from the large and branched antennæ, which serve as swimming organs. They are all small, and the carapace forms a bivalve shell inclosing the greater part of the body, this carapace being an extension of the dorsal surface of the head segments. An example of the order is the water flea (*Daphnia pulex*), to which *Acanthocercus*, represented in the figure on p. 3251, is nearly allied. Here the body is narrowed in front, and at the posterior end, where the carapace (S) is deeply notched, is the tip of the abdomen (C), bearing the pair of rigid barbed setæ, from which the genus takes its name. At the front of the head (A) is a large compound eye (O), and the branched and plumed appendages projecting from beneath the sides of the head are antennæ (R, T). The first pair of antennæ are small and simple. The jaws consist of the mandibles and the first pair of maxillæ, the second pair of maxillæ being obsolete in the adult. The thorax comprises five segments, each bearing a pair of leaf-like swimming limbs. The abdomen consists of three segments and is limbless. The males of *Acanthocercus* are smaller than the females and much rarer, being generally met with in the autumn. Eggs are laid both in summer and winter and are passed into a brood pouch, separating the upper surface of the thorax from the backward extension of the carapace. Here the summer eggs hatch, but the winter set are inclosed in a kind of capsule developed from part of the carapace. This capsule, called the *ephippium*, is cast off with the next molt of the mother's integument, and falling to the bottom of the water gives exit to the embryos, which hatch in its interior. Another type is the glassy *Leptodora hyalina*, so called on account of its semitransparency, which inhabits the open water of fresh-water lakes. The shell is so much reduced as scarcely to envelop the animal.



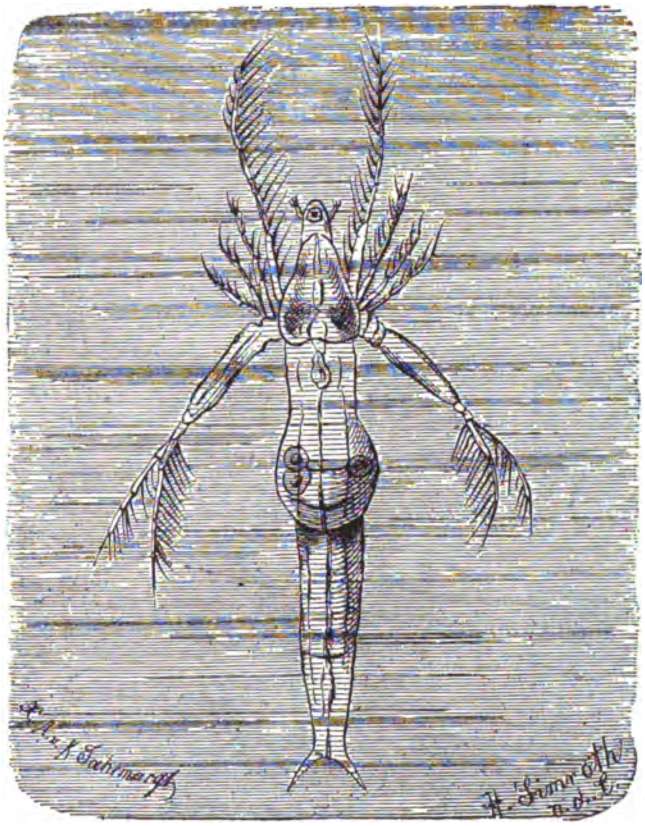
EGG CAPSULE OR *Ephippium* OF WATER FLEA, *Acanthocercus*. (Much enlarged.)

LEAF-FOOTED GROUP — Order PHYLLOPODA

Some of the members of this group are relatively large, the body being long and composed of a great number of segments, of which the thoracic, and sometimes the abdominal, are furnished with leaf-like gill-bearing appendages.

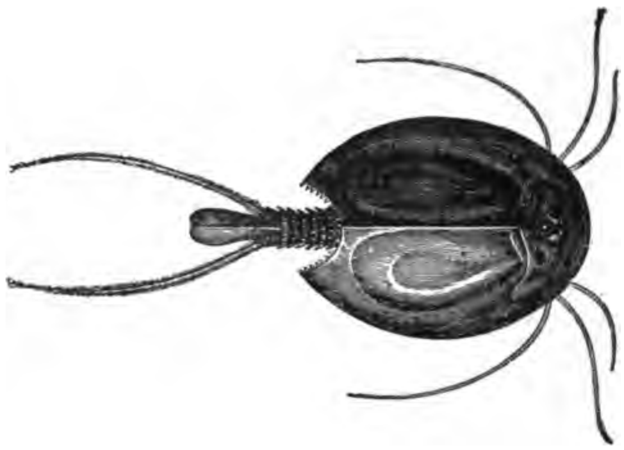
In the family *Apodidæ*, containing the genera *Apus* and *Lepidurus*, the anterior end of the body is covered with a carapace, projecting from the head over the free

segments of the thorax. The hinder border of this carapace is deeply cut out, and near its front end there is a pair of contiguous compound eyes. The mouth is bounded in front by a large upper lip and behind by a deeply cleft *metastoma*, or lower lip. Both pairs of antennæ are short. The jaws consist of a pair of mandibles and two pairs of maxillæ; these are followed by eleven pairs of thoracic limbs, and there are appendages on the abdomen, sometimes numbering as many as fifty-two pairs. The last segment of the abdomen bears a pair of long filaments, and sometimes, as in *Lepidurus*, a distinct caudal plate. These crustaceans occur in the fresh waters of most countries. They swim on their backs, using the legs as



THE GLASSY LEPTODORA, *Leptodora hyalina.*
(Enlarged twelve times.)

paddles; and the eggs are capable of surviving long periods of drought when embedded in dried mud. In the second family—the *Branchipodidæ*—the body is also elongate, but there are no appendages to the abdomen, which consists of nine segments, while there are eleven pairs of thoracic appendages. The headshield is not developed backward, and the large separated eyes are supported upon distinct stalks. In the male, the second antennæ are converted into claspers. These forms likewise swim upside down. Some (*Branchipus*) occur in fresh waters, but others (*Artemia*) prefer briny pools and flourish in water so strongly charged with salt as to be fatal to other crustaceans.



SCALE-TAILED APUS, *Lepidurus*
(Natural size.)

Class Prototracheata

This term is applied to the group now claiming attention, because in many respects it occupies a place between the Tracheates and Worms, and is consequently regarded as allied to the ancestral form from which all Tracheates have been evolved. Unlike the true Arthropods, the limbs are not jointed; and the tough integument is covered with bristle-bearing papillæ, but is not divisible into segments. The long body is shaped like that of a caterpillar or slug, and to the sides of its lower surface are attached a number of short more or less conical legs, each tipped with a pair of strong claws. The head is supplied with a pair of stout longish antennæ, at the base of each of which, on the outer side, is an eye. On the lower surface of the head is placed the mouth, supplied with fleshy lips and two pairs of toothed horny jaws; and on each side of the head there is a modified appendage known as the oral papilla. The chief features to note in the internal organization are the presence of segmentally arranged kidneys — one opening at the base of each leg — and the wide separation of the two strands of the ventral nerve chord. This last characteristic is found in some of the lower worms, and the numbers of paired kidneys in the higher members of the latter group. The class contains only the single family *Peripatidæ*, which has a wide but somewhat singular distribution. The genus *Peripatus*, for example, is spread over the West Indian islands, ranging from Nicaragua through the northern parts of South America to Chili, and has also a single representative in Sumatra; while *Peri-*

a. MALE OF *Branchipus grubei* (natural size); *b.* FEMALE OF *Branchipus grubei* (natural size); *c.* MALE OF BRINE SHRIMP, *Artemia salina* (enlarged).

patopsis is confined to Cape Colony, and *Peripatoides* to Australia and New Zealand. These three genera are easily distinguishable by external characteristics, and differ both in internal features, and also in embryonic development. Nevertheless, all the species seem to be closely similar in habits, living beneath the bark of trees, in the crevices of rotten stumps, and under decaying leaves, but always in damp localities, being exceedingly susceptible to drought. Locomotion is slow, and effected entirely by the legs, the body being kept rigid; and in walking every inch of the track is carefully explored by the antennæ, which are so sensitive that they seem able to learn the nature of an object without actual contact. The sole function of the eyes seems to be to distinguish light from darkness, though it is possible that being nocturnal the animal may be able to see to a slight extent in a subdued light. When irritated, these creatures spurt from their oral papillæ a quantity of slime at the offending object, and with the same sticky substance entangle their prey, which consists of small insects. A specimen of *Peripatopsis capensis* has been seen to overcome a small scorpion by this means. This slime — secreted by two long glands extending from the oral papillæ far back into the body — can be ejected to a distance of about a foot. Curiously enough it will not adhere to the skin of the *Peripatus* itself. In one of the Australian species (*Peripatoides oviparus*) the mother lays her eggs in damp spots; but, as a rule, the young are born alive, and although the mother takes no special notice of them they crawl upon her back for protection.

Peripatus edwardsii (natural size, from life).

CHAPTER VIII

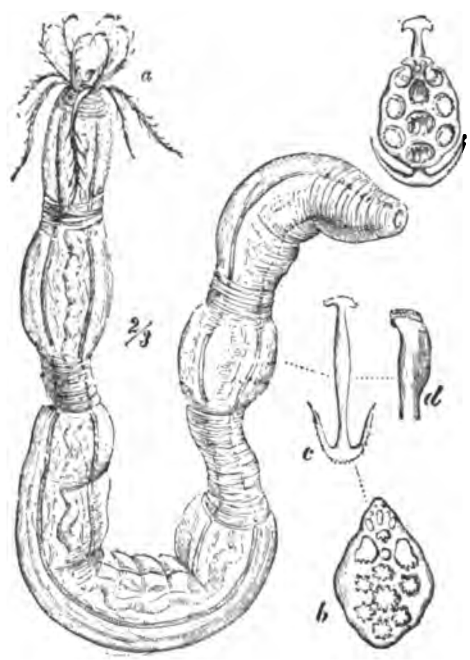
STONE LILIES, STARFISHES, SEA URCHINS, AND SEA CUCUMBERS
Subkingdom **ECHINODERMATA**

Characteristics of the Group

THE starfish, the sea urchin, the brittle star, the feather star, and the sea cucumber — especially the three former — are well known to all frequenters of the seashore; while the fossil sea urchins of the Chalk, whose flint casts are so common on the downs of England, the so-called screw stones found in the Mountain Limestone, the pentremites and crinoids, whose remains are so abundant in some parts of North America, are no less familiar to dwellers inland. Though these animals differ much from one another in shape, a slight scrutiny will discover many points in which they resemble one another and differ from other creatures. They and their relatives are, therefore, placed in one great group of the animal kingdom, the Echinodermata,— a group corresponding in importance to the Mollusks, or the Vertebrates. This group is, in fact, more clearly defined, and more widely removed from other groups than either of the two mentioned. If a starfish, or any of the animals named above, even a sea cucumber or holothurian, be touched with the finger, its skin will be found to have a rough surface; this is due to the circumstance that it contains a crystalline deposit of carbonate of lime. In a sea urchin, a brittle star, or a feather star, this deposit is in the form of little plates, which build up a more or less rigid test; whereas in the starfish it usually forms a kind of scaffolding, between which there stretches the more yielding, leathery skin. In the ordinary sea cucumbers the deposit consists only of small spicules, which roughen the outer surface, and grate when the skin is cut with a knife. If a thin slice of the skin of one of these animals be cut and examined under a microscope, the spicules may easily be seen lying in its middle layer. It is this same deposit that forms the spines of a sea urchin and the stalked column of a crinoid; and it is this which has enabled so many of the Echinodermata to be beautifully preserved as fossils. To this characteristic is due the name of the group, derived from the Greek, *echinos*, a hedgehog, and *derma*, skin. Many animals have some deposit of lime, such as the shells of the Mollusks, and the bones and teeth of the Vertebrates, but the deposit of the Echinodermata differs in two characteristics: first, that its microscopic structure is that of a mesh work, or rather or a beam-and-rafter work, since it is deposited in the spaces of a network of soft tissue; secondly, that each element, whether a spicule or a plate, is, despite its trellised structure, deposited around regular lines of crystallization. Owing to these characteristics, the minutest portions of an echinoderm skeleton can be recognized, even when fossilized. This tendency of the Echinoderms to deposit lime is not confined to the skin, the walls of the internal organs being often strengthened

by a deposit of similar structure. Although, as has been said, each element of the skeleton follows the laws of the typical crystallization of carbonate of lime, yet the structure of the trellis work varies greatly, and is often characteristic of the species in which it occurs. Thus, the species of sea cucumber can be distinguished by the shape of their spicules; and the same is said to be the case with those sea urchins that deposit spicules among their viscera.

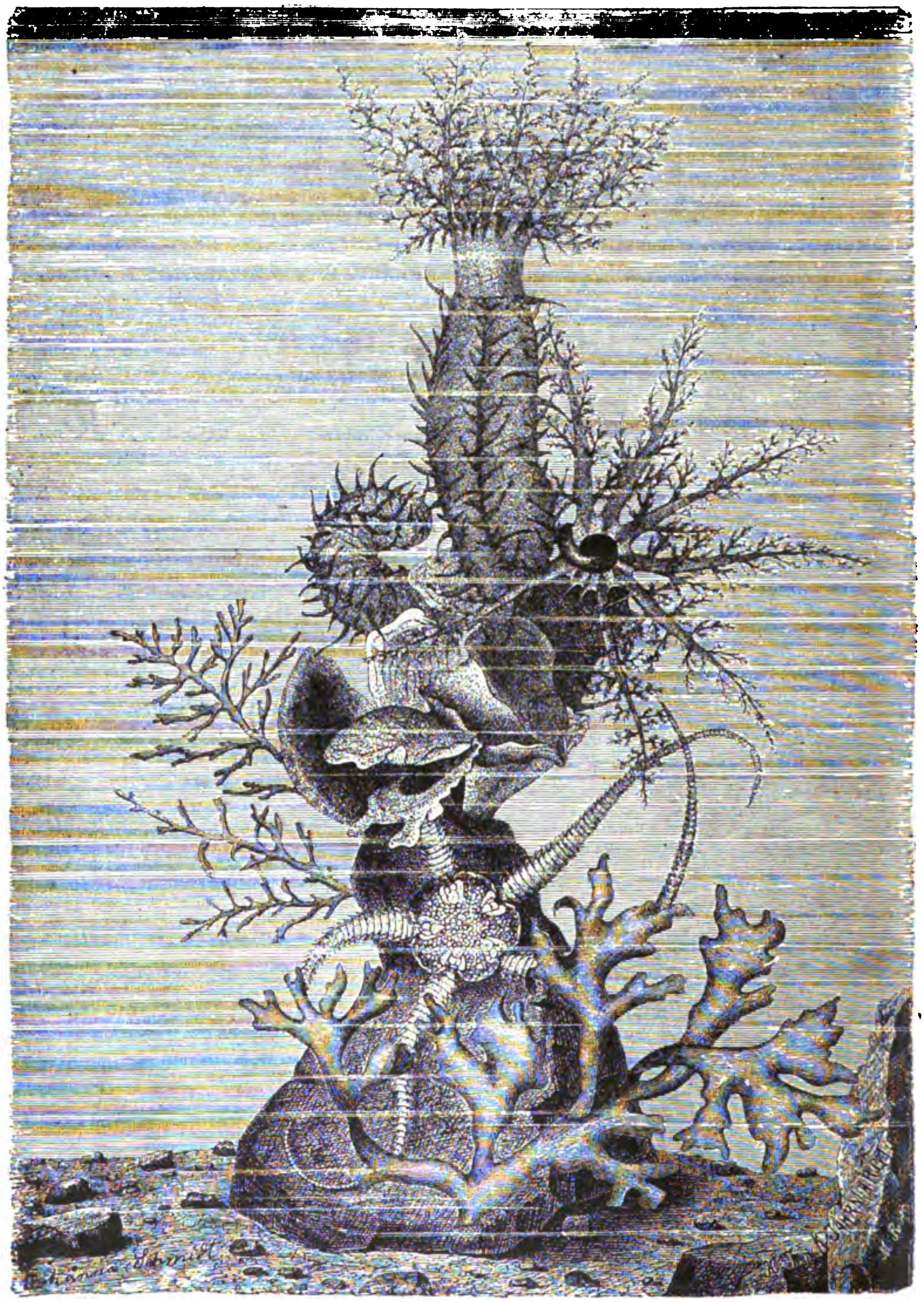
The next feature noticeable is the radiate structure in many cases giving to the animal a star shape, to which the common names starfish, brittle star, and the like are due. The ordinary red starfish or crossfish of the English coasts has five distinct rays or arms; and this number five, to a greater or less extent, controls the arrangement of the organs in the majority of the Echinoderms. It can be detected even in a sea cucumber or holothurian, where, beside the feathery tentacles of the head, are rows of shorter sucker-like processes, which extend the length of the body; these rows being five in number. The internal organs, as will be seen later on, are variously affected in the various classes of the Echinoderms by this five-rayed symmetry. A radiate arrangement is not, however, confined to Echinoderms, as it also occurs in jellyfish and sea anemones. Hence those animals were once grouped with the Echinoderms, under the title of Radiata. But, if a sea cucumber or a sea urchin be opened, there is a marked distinction between it and a jellyfish, in the presence of an intestine, shut off from the rest of the body cavity, and often coiling round inside it. In this respect the Echinoderms resemble all the animals that have been dealt with in the preceding pages, whereas the jellyfish and their allies differ from them in having no body cavity separated off from the stomach and its processes. Moreover, Echinoderms resemble the higher animals in the possession of a system of branched tubes conveying blood through the body.



ANCHOR SEA CUCUMBER (*Synapta*).
a. Tentacles round the mouth; *e.* Anchor and plate-shaped spicules; *b, c, d.* Similar spicules of an allied form.

Examining a starfish or a sea urchin, one sees, on the under surface of the rays in the former, and passing in five bands from top to bottom of the latter, a number of small cylindrical processes, which are usually gently waving about like trees in a wind. They lie in each band, or in each ray, along two rows, with a clear space between, like trees on either side of an avenue; hence the whole band of them in each ray is called an ambulacrum (garden walk). Most of these little processes end in sucker-like discs, which the animal can stretch out and attach to smooth surrounding objects; and it is thereby able either to hold itself firm against waves

or currents, or to pull itself along. Hence these processes are usually called tube feet; but sometimes they end in a point, and cannot assist in locomotion,



SEA CUCUMBERS AND A BRITTLE STAR.

though they may help respiration, when they are sometimes called tentacles. If a single foot be touched, it immediately shrinks up, and if the touch be vigorous, the adjacent tube feet probably follow its example. Tube feet torn from the animal sometimes continue their waving motion, showing that this is, partly at least, due to muscular action. Their movements are also caused by the squeezing of a fluid into them; for each foot is like an India rubber tube closed at the end, and passing through the test (as the shell of the sea urchin is termed) to join with one main tube, which runs along under the ambulacrum in a radial direction; and before it joins the radial canal, each tube foot gives off a small swelling likewise, filled with fluid, so that when this swelling is contracted all the fluid is squeezed up into the foot, and pushes it out like the finger of a glove when blown into. The radial canals pass along under the ambulacra till they join in a ring canal surrounding the mouth. Eventually this circular canal is connected with the surrounding water by a canal passing right across the body cavity to the other side of the animal, near the vent, where it opens to the exterior through a plate pierced with a number of pores. This plate is called the madreporite, and the canal leading to it — owing to the limy deposits formed in its walls — the stone canal. This whole system of fluid-filled canals is termed the water-vascular system. The foregoing description refers to its arrangement in a starfish, or regular sea urchin; but the system occurs, with various modifications, in all Echinoderms, and is one of the features that separate the group from other animals.

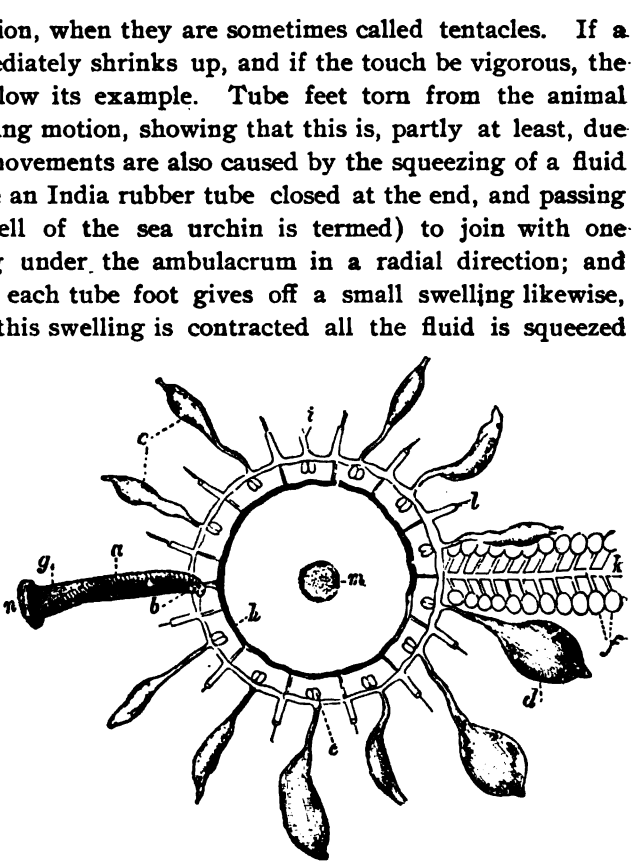


DIAGRAM OF AMBULACRAL SYSTEM OF A STARFISH.

f. Small swellings connected with the tube feet; *k*. The radial canal with which they unite; *e*. Ring canal into which the radial canals open; *c*, *d*. Membranous sacs that serve as reservoirs for water from radial canals; *a*. Stone canal, leading from ring canal to the madreporite, *n*; *m*. Mouth.

The Echinoderms are also peculiar in the possession of three, or perhaps four, different systems of nerves, of which three, or at least two, are present at the same time. One system supplies the skin, the tube feet, and the intestine; its chief parts being a ring round the mouth, and radial nerves radiating therefrom. The second system has a similar arrangement, but lies deeper, and supplies the internal muscles of the body wall. The third system, which is most fully developed in crinoids, starts from the other side of the body, opposite to the mouth, and supplies the muscles that work the arms and stem. If the arm of a starfish be opened from the back, there will be seen a pair of pleated extensions from the stomach. If these be removed, there will be exposed a pair of orange-colored tubes, somewhat branched

and knotty, which communicate with the exterior at the angles between the rays. These are the generative glands. In all Echinoderms, except sea cucumbers, these glands are affected by the radiate structure of the animals; in crinoids the generative products are even produced in the extremities of the arms.

Distinction of the Classes

Having glanced at those points of structure in which Echinoderms resemble one another and differ from the rest of the animal kingdom, we may shortly examine the main characteristics in which a sea urchin, a starfish, a crinoid, a brittle star, and a sea cucumber differ from one another. First may be noted obvious differences in form and in position in the living state. In an ordinary sea cucumber (as shown in the illustration on p. 3258) the body is cucumber shaped, with the mouth at one end and the vent at the other; between these run the five ambulacra, one or two of which are often more developed than the others, so that the animal crawls along on that side of its body, with its mouth foremost. A sea cucumber has no arms or projecting rays, but its mouth is surrounded by a circlet of tentacles, often branched, which can be retracted at will. A regular sea urchin, such as the sea egg (*Echinus*), shown in a later figure, resembles a sea cucumber in being without projecting rays; but it is more spherical in shape, and moves with its mouth toward the sea floor. On the other hand, in a heart urchin (*Spatangus*), which moves through and swallows mud and sand, the body has become transversely elongate; that is to say, the long axis is at right angles to the position it occupies in a sea cucumber; the mouth having moved a little forward, and the vent being transferred from the top of the body to its lower surface, so that both the mouth and vent lie on the under surface, at either end of the long axis. In a starfish, as in a regular sea urchin, the mouth is in the centre of the under surface, while the vent is almost in the centre of the upper surface, although absent in a few forms. The body is either markedly pentagonal in outline, or more or less star shaped. In the latter case it is said to consist of a central disc extended into arms, as in the illustration on p. 3271. The number of these arms varies from five (*Asterias*) to over forty (*Heliaster*); but in each species with more than six arms the number may vary slightly, although constant during the life of the individual; in *Labidiaster*, however, fresh arms grow out even in the adult. A brittle star (illustrated on p. 3258) resembles a starfish in which there is a sharp distinction between arms and disc; the mouth being on the under surface, but the vent wanting. And whereas the arms of a starfish are simply extensions of the body, containing the generative glands and processes from the stomach, those of a brittle star are mere appendages to the body, with a stout internal skeleton of separate ossicles, working on one another by well-developed muscles, and containing only blood vessels, water vessels, and nerves. The arms of the brittle stars are nearly always five in number, though sometimes there may be from six to eight. As in the starfish, the arms are unbranched, except in the family *Astrophytidæ*, where they fork ten or twelve times, and where the numerous branches interlace so as to form a kind of basket work all round the disc, whence these animals are called basket fish, or medusa head starfish. A crinoid (illustrated on p. 3264) differs markedly from a sea urchin, starfish, or brittle star, in that the mouth faces upward; the vent being also on the upper surface. This position is due to the fact that, so

far as we know, all crinoids are at some time of their lives attached by a stalk to the sea floor, or some other object, so that the mouth and vent naturally move up to that side of the body furthest from the stalk. This fixed state of existence has also caused the development of arms, five in number, but often forked many times, which arms stretch out from the body on all sides of the mouth, and contain extensions of the nervous, blood-vascular, water-vascular, and generative systems. The representatives of the tube feet are arranged along the sides of these arms, on their upper or oral surface, and between them is a groove, which is lined at the bottom with cilia, or extremely minute hair-like processes, that keep waving in the direc-

GROUP OF STONE LILIES (PENTACRINIDS).

tion of the mouth, and so maintain a constant stream of water toward the latter; such water containing the minute animalculæ and fragments of decaying organic matter on which the crinoid feeds. The extinct cystids and blastoids have their mouth in a similar position to that of the crinoids, and for a similar reason, but have not similarly branched arms. In the blastoids five grooves radiate down the body from the central mouth, and from the sides of these grooves there spring small, jointed, but unbranched processes, called pinnules. The stem of the blastoids is very short, so that when the pinnules have been lost, as is usually the case, the five-grooved body looks like a bud, whence the name of the class. It is difficult to describe a cystid as having any definite shape, for the various animals to which this

name is applied differ greatly from one another in structure. Echinoderms are built upon one or other of the plans of structure just described. Moreover, the animals formed upon any of these plans are found to agree with one another and to differ from the rest in yet other features. Hence zoologists have divided the Echinoderms into seven classes, each of which is again divided into orders.

Mode of Life All Echinoderms live in the sea, where they find in solution the lime salts from which their skeletons are built. None have become modified for a truly fresh-water existence, and in this respect they are peculiar among animals; a few holothurians, however, are found in the mud of some estuaries and brackish-water lagoons, while a starfish (*Asteracanthium*) and a brittle star (*Ophioglypha*) occur in the brackish waters of the Eastern Baltic. Neither can Echinoderms live on land, and though they may exist for a short time out of the water when left by tides, still it is only in the water that they can breathe or feed. In the sea, however, they have a universal distribution; from icebound seas to the Equator; from shallow shore pools to mid ocean; from the surface to the abyss; on rocky shores, sandy beaches, muddy shoals, and bottom oozes, among the roots of the mangrove, or in the meadows of seaweed. This universal distribution renders their study one of importance for the geologist, especially as their calcareous skeletons are readily preserved as fossils. Their remains are known from rocks of every age in which animals are known to have existed, and even the spicules of sea cucumbers have been found as far back as the Carboniferous period. Moreover, the rapidity of evolution in the group, and the short period of time during which any one species was in existence, combined with the wide area of distribution possessed by many species, render these fossils of great value for the correlation of strata in different countries.

The Cystids — Class Cystidea

The Cystidea have been extinct since the Carboniferous period. Not only are they among the oldest animals, but there is reason to suppose that they approach more nearly the primitive forms from which all the classes of the Echinoderms were derived. Many have not that regularity of symmetry which characterizes later Echinoderms. Such forms as *Echinosphæra*, commonly called the crystal apple, are mere round balls composed of a number of plates in which it is hard to see any arrangement. Some of them seem to have been unstalked, while in others the stalk is quite short. The arms are short, and vary in number, bearing but slight relation to the plates of the test. In some, however, such as *Glyptosphæra*, the ambulacral grooves, though rather irregular, are five in number and lie on the surface of the test, all meeting at the mouth, which is placed in the centre of the upper surface. Other cystids seem to be composed of an irregular number of plates; but they have become more definitely radiate in structure. Some, like *Agelecrinus*, are flat circular forms, which live attached by their under side to the flat surfaces of shells, and which have five distinct ambulacral grooves radiating from the central

mouth on the upper side; while others, like *Mesites*,—which resembles *Agelecrinus* in the arrangement of its grooves,—were attached, if at all, by only a small part of the under side. Yet other cystids are definitely attached by well-developed stalks, and have their bodies inclosed by a limited number of plates arranged in regular order. Some of these present a six-rayed symmetry, such as *Caryocrinus*, while others are governed by a five-rayed symmetry, such as *Lepadocrinus* and *Porocrinus*. Both of these groups have, as a rule, better developed arms, which sometimes branch, and are usually five or six in number according to the symmetry of the cup. Hence these forms are much more like the crinoids than are the other cystids.

In other Echinoderms the rays with their numerous tube feet help the respiration of the animal, but these were absent or very slightly developed in the cystids. There are, however, other structures that are supposed to have served the same purpose. In some (*Aristocystis*) the plates of the test are pierced by simple pores, while in others (*Glyptosphæra*) these pores are in pairs; but in either case the pores are scattered irregularly over the body, and possibly gave passage to minute tube feet. The development of these and their concentration in certain areas of the test would produce an arrangement not unlike that of other Echinoderms. Other cystids have certain portions of the test pierced by slits (*Lepadocrinus*), and it seems probable that these permitted the surrounding water to pass in to the membrane, lining the interior of the test. These structures are called hydrospires (water breathers), and somewhat resemble the cribriform organs found in some deep-sea starfish of the present day (*Porcellanaster*), figured later on. Structures called hydrospires have also been described in such cystids as *Caryocrinus* and *Echinosphæra;* but it is doubtful whether these actually subserved respiration, although the true hydrospires may have been evolved from some such undeveloped structures.

Another point of interest in the cystids is the light they throw on the origin of the crinoid stem, which is formed of a series of flat rings. The simple round plates, with a circular hole through the middle, are often called St. Cuthbert's beads, while those marked with five petals, so common in the Lias at Lyme-Regis, have been termed starstones. Technically the two kinds are distinguished as Entrochi and Astroites. They are familiar in the polished slabs of Mountain Limestone, in which it may be seen how the long stem is formed of a number of these round ossicles jointed together, and pierced throughout by a narrow canal. The ossicles are joined by ligaments passing right through their solid substance, and endued with slight muscular power; the central or axial canal serving for the passage of blood vessels, which are surrounded by a sheath of nervous tissue that controls the movements of the stem. By one end the stem is attached to the sea floor, either by a flattish incrusting extension of its calcareous substance, or by a number of fine branches or rootlets, as in the root crinoid (*Rhizocrinus*), herewith figured. By the other end the stem is attached to the plates forming the cup inclosing the body of the animal, and it is at this end that it grows, by the constant development of new ossicles between the cup and the upper segments of the stem. Now, if we suppose that the crinoids, like other Echinoderms, sprang from sac-like ancestors with a number of

irregular and small plates, it is difficult to understand how such a stem was evolved; but the mystery is elucidated by some of the cystids and older crinoids. First, it may be noted, that in those cystids possessing a crinoid-like stem, as well as in many of the older crinoids, the axial canal of the stem is much larger than it is in later forms. Secondly, that in many older crinoids, the ossicles of the stem, instead of being simple rings, are generally composed of five equal parts. In other words, there are five radial sutures or joint surfaces, running the whole length of the stem and dividing each ossicle into five parts. These sutures are more conspicuous toward the root end of the stem, which was of course the first to be formed in each individual. Thirdly, examination has shown that in some of these stems, especially toward the root end, the five portions of each ossicle do not lie regularly above the five portions of the underlying ossicle, but alternate with them to a certain extent, just in the same way as the circlets of plates that make up the cup of a crinoid alternate with one another. These facts alone would lead us to suppose that the stem was originally composed, like the cup still is, of a series of circlets of small plates, five in each circlet, and alternating with one another; that the stem was, in fact, nothing more than a continuation of the cup, with essentially similar structure. Turning to the cystids, we may see how this view is confirmed and extended. In certain forms, such as *Trochocystis*, that part of the stem next the body consists of a double series of alternating plates, which are thin and inclose a large hollow. In *Arachnocystis* the whole stem consists of four or five series of alternating plates. In *Dendrocystis* the plates forming the upper part of the stem can only be distinguished by their smaller size from those forming the cup; below they merge into the normal series of single ossicles. *Cigara* is the name given to a stem entirely composed of small irregular plates. We may, therefore, conclude that the stem originated as a portion of the body of the animal, elongated, and gradually becoming more and more regular in its structure. The curiously elongate and irregularly plated form called *Pilocystis* may represent the earliest stage in its evolution, before one can even say that a stem is differentiated at all.

LOFODEN ROOT CRINOIDS.
(One and one-half natural size.)